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THE HONEYBEE*

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The bee and the ant, from the days of antiquity, have probably been of greater interest to man than any other insect. None has been held up more before man, than these two, for its virtues; none has been more widely eulogized by poets, philosophers, and other leaders of human thinking. We have reasons to believe that thousands of years ago, mayhap, before the days of the Great Pyramids, beekeeping was an established occupation of man. Paintings and carvings found on the Iberian Penninsula would indicate that in Paleolithic times, 10,000 to 15,000 years ago, man gathered honey as a food.

The story of honey, a "food fit for the gods," is inextricably interwoven with the ancient rituals and folklore of numerous peoples, extending from central Europe to India, finding its greatest expression among the early Mediterranean and Asia Minor civilizations. Among the Persians honey was a sacred food. In the hieroglyphics of the ancient Egyptians the symbol of the bee stood first, as the symbol of royalty. The cuneiform tablets of the Sumerians and Babylonians, as well as the Vedas, sacred writings of India, abound with references to the bee, its honey, its wax, and the various rules and regulations governing the same.

Honey, as a tribute in warfare, is referred to time and again in the pages of history. Alexander's triumphant march into India

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For practical help in the study of the honeybee get the 32-page booklet "Some Lessons about Bees." SCHOOL SCIENCE AND MATHEMATICS, 3319 N. 14th St., Milwaukee, Wis. 25 cents.

brought forth a tribute of "honey and wax," and the Romans, we are told, required the Corsicans to pay 200,000 lbs. of wax yearly over a long period. According to old Saxon law, the theft of a swarm of bees was punishable with death. On our side of the Atlantic we read of the ancient Mayas and Aztecs placing a tribute of honey on conquered tribes.

Of like interest appear the stories, reaching back into history a thousand years, of bees being used in warfare. That a hive of bees dropped from some high castle wall upon a group of courageous horsemen about to force the heavy gates below, may cause consternation at the critical moment, might well be imagined. The Turks, a century and a half ago, are credited with a similar technique. They carried hives up on the masts of their ships, ready to be released should the ship be forcefully boarded by the enemy. As late as the World War, we find the Germans employing colonies of bees against the British attackers in the African campaigns.

Since Bible times the honeybee has been a symbol of industry, and its honey a symbol of plenty. We find Canaan referred to as the "land flowing with milk and honey," and one of the earliest references to honey as an article of commerce and trading relates to the Jews engaging in such trade at Tyre in Phoenicia. When the sons of Abraham were sent to Egypt to buy corn, they took to the rulers of Egypt some of Canaan's famous honey. So deep seated in folklore have the references to "milk and honey" as man's earliest foods become that some authors feel such references do not necessarily apply to the presence of apiculture, but rather are synonymous with fertility, plenty, and contentment. It is of interest that some authorities hold the Bible itself makes no direct reference to beekeeping as such. On the other hand, the ancient Jews were wont to place honey before a guest as a sign of welcome, extending to him the land's greatest luxury. In fact, the word honey itself is derived from the Hebrew word "ghong," meaning "delight." As Maeterlinck points out, Virgil, in his writings, has probably best summed up the early traditions of the honeybee. Aristaeus, one of the ancient Greek divinities, is credited with having introduced the cultivation of bees. And, we are told, it was Ceres, regarded as the "honey-dispenser," who, through her union with the rain god, Zeus, brings us our fruitful seasons.

Another angle of interest is the traditional reference to the honey and the sting of the bee as a cure-all. As has already been

stated, early writings abound with elaborate rituals involving the use of the bee and its products, all the way from scaring away an evil spirit to the ceremonies involved in reincarnation. The Christians of Ethiopia are said to smear honey on the baby's lips as part of the baptismal ceremony. The Greeks and Romans used honey in embalming. The Syriac Book of Medicines mentions honey in over 300 prescriptions and wax in over 50. A recent writer on apiculture refers to honey in its various preparations as a remedy for:

1. coughs and colds
2. dyspepsia
3. erysipelas
4. frostbites
5. burns and scalds
6. sore eyes
7. consumption
8. tapeworm
9. asthma
10. constipation
11. cancer
12. worms
13. freckles

Much is written of the bee sting as a cure for rheumatism. One British hospital claims that the formic acid content has been successfully used in this respect. The French scientist, Lautel, refers to his success in using the sting in the treatment of rheumatism, eczema, and leprosy. A relative of mine, suffering severely with rheumatism, claims to have cured himself by releasing a handful of bees under the bed covers from time to time. And finally, one rather realistic author states, "Facts already brought to light show that an intoxicated person is quickly sobered by a beesting. . . . "

Statistics on the extent of apiculture are rather variable. There are perhaps 800,000 beekeepers in the United States, involving about four and one half million colonies. The total marketable output is probably about 100,000 tons of honey annually, worth about $20,000,000, with another $2,000,000 for marketable wax. It has been said that honey and beeswax are produced over a wider geographical range than any other agricultural crop. Bees are kept in the tropics as well as in the temperate zones,—from New Zealand in the south to Alaska in the north. We find these little winged laborers toiling in the deserts, and in the swamps, up on the mountains and across the open plains.

Little do we realize the labor involved as these insects gather in man's oldest sweet. Each pound of honey involves about 75,000 miles of flight, or three times around the earth. The aver-

age bee probably produces less than quarter spoonful of honey all her life. Were she to undertake to gather a pound, she would have to labor every day for a period of eight years. It has been estimated that our total honey output may involve several hundred billion little workers a year.

It is, however, generally recognized that the value of the bee is far greater than is measured by the honey she produces. Authorities tell us that our annual fruit crop, valued at about $600,000,000, would be negligible without the various pollen carriers, chief among whom is our honeybee. Experiments with apple trees showed that trees exposed to bees produced from 40 to 50 times the apples that unexposed trees did. Darwin noted that 20 heads of white clover visited by bees produced 2,290 seeds, while 20 heads so protected that bees could not visit them produced not one seed. Biologists estimate that were we to eliminate all bees, the varieties of plants to disappear from the earth might well run into the thousands. Verily, these tiny creatures have justly been named "the priests of the flowers," and pictured through the ages as a symbol of fertility.

The honeybee is an insect and belongs to the Order Hymenoptera. Some authorities estimate that there are about 4,500 varieties of bees, if we include all the Apiens. Our attention, however, is centered on the common honeybee, *Apis mellifica*, meaning "honey-maker," or *mellifera*, as it is also called, meaning "honey-bringer." It, among all its relationship, has developed the most unusual social structure.

Maeterlinck is inclined to agree with many other biologists that Prosopis, a little, wild bee found quite widely distributed, is typical of the probable ancestor of all bees of today. Prosopis is a solitary creature, almost naked of hairs, with a relatively short tongue, without pollen baskets, weak of claw and mandible, and unable to dig into the earth or produce wax. Its entire efforts result in the erection of a few awkward cells in the tender pith of a dry berry.

The gradually varying degrees of the fraternal instinct in the bee family may well be traced in some of the other relatives. There are a number of species that carry on a solitary struggle during the summer months, only to huddle in groups as the cooler weather approaches. Still other forms tend to create a structure in which a common entrance is used by all, yet each bee collecting and storing its individual supplies.

Our hairy, buzzy bumblebee spends the winter as a solitary

female, but develops a loose social structure as the wearmer weather approaches. The swarm or colony lives and works together, but compared with the honeybee, under laws less well defined or obeyed. It is a social life, but with the individual not entirely subdued before the needs of the race.

Various of the tropical, or stingless, bees have developed a society closely approaching the honeybee in many ways. The three types, the undeveloped workers, the fertile queen, and the drone, are present. Division of labor is carried to a finer degree than among the genus ***Bombus***, the bumblebees, but not to the point where *Apis mellifica* and its varieties have carried it.

Among the various honeybees, the Italian may be taken as one of the best examples of a social insect. Each normal colony includes one queen, a fertilized female, whose sole function is to carry on the race, namely the laying of the eggs. At the height of the season this may mean as high as 2,000 or 3,000, or even 4,000 eggs per day.

The drones, or males, present only during the summer months, or mating season, likewise serve but one purpose, the fertilizing of the virgin queen, a duty which perhaps but one drone out of a thousand will ever perform, only to die in the act, its entrails torn asunder. An old tradition well describes the marriage ceremony as one in which the husband becomes a corpse and the bride becomes a widow.

It is the workers, or undeveloped females, to whose lot falls all of the real labor of the colony. And it is here, in the well-balanced division of labor where the uniqueness of the bee's social structure impresses itself upon us. First there are the collectors or foragers. Among these are some who gather pollen, some who carry the nectar, others who seek the propolis, a glue-like substance, and still others who obtain the water. At the entrance to the hive stand the guards, ready to challenge any stranger who dares enter their domain.

Behind this entrance is indeed a "bee-hive" of industry. The queen has her ladies of honor ever about her. The nurses care for the tiny larvae, feeding and cleansing them constantly. An army of architects and masons are ever building new structures, while the wax makers furnish them with building materials. The chemists are there, putting a tiny drop of formic acid into each cell of honey to help preserve the contents, and when all is prepared the sealers cap over the cell for future use.

But health and sanitation is not neglected. The sweepers carry

out all refuse, keeping the abode spotlessly clean, with the bearers aiding them when it is necessary to remove any corpses, the bodies of those who have labored until they dropped in their tracks. And all of these might labor under terrific difficulties were it not for the fanners constantly on the job. It is these, who through a constant, rhythmic motion of the wings furnish the ventilation for the entire structure, carrying on a complete air-conditioning setup, as regards fresh air, temperature and moisture content.

Nor have we here a mere division of labor, with an iron clad impulse of "thou shalt do this and thou that." Wherein lies the miraculous regulation of these various duties, many of them often shifted as demands vary? Maeterlinck speaks at length of the "spirit of the hive," for lack of a better term to describe that prime motivating force, whatever it may be. For the queen does not rule—she is a mere egg-laying machine. She issues no orders, but herself obeys that "spirit" meekly, as do all of her subjects. What mysterious force prompts her to regulate her egg laying, and hence the births, to correspond with the flowers out of doors—which she never sees? What force compels her to create her own rivals at one time, or her subjects to destroy the royal brood at another, as circumstances demand? What power or intuition tells the queen to lay a fertilized egg into one sized cell, and with the same body, an unfertilized egg, destined to be a drone, into another—always regulating this ratio to match the world without? Who decrees when the noisy, clumsy, gluttonous loafers, the drones, each requiring 4 or 5 workers as caretakers—who decrees when these shall be tolerated, and when they shall be mercilessly massacred? Who would describe as a blind, primitive impulse, a power that is ever and anon taking note of the constantly changing, constantly new, conditions?

Who selects the scouts when the colony swarms, whose task is to seek new abodes? And when these various scouts return, each with her message, by what mysterious process, after hours of hesitation, is the choice finally made? Yea, and who decides at the hour when the home itself is being torn asunder, who shall remain loyal to the departing queen, and who to the victorious one?

The building of the hexagonal combs has attracted much attention. Not only the six-sided cell, but the bottom of each cell with its three planes dovetailed into the bottoms of the cells on the opposite side of the comb are worthy of note. Much has been

written to point out that the greatest mathematicians have not improved on the bee's engineering talent to get the most space and greatest strength out of a given unit of precious building material. Buffon, it is true, argues that the bee starts with a circular cell, that the proximity of the neighbor cells results in the six-sided figure. Boil peas in a tightly closed pot, he reminds us, and the globular peas attain a hexagonal shape. Is this comb a reasoned process, or is the insect being carried on by an instinctive impulse? The cells are precise structures, yet the combs as a whole are very shrewdly adapted to any shaped abode, once that abode has been accepted as home.

Just what degree of intelligence is involved, or is blind instinct everything? Is the queen blindly loyal to her subjects, or are they blindly loyal to her? Maeterlinck expresses his view that these Hymenoptera "of all the inhabitants of this globe, possess the highest degree of intellect after that of man." Yet in another instance he relates that bees placed in a glass bottle, with the lower end of the bottle towards the lighted window, persisted in flying towards the light and glass until they dropped exhausted, whereas a group of flies similarly treated found their way out by scouting about until they had discovered the entrance.

We come now to the most basic principle behind this "spirit of the hive,"—the entire submergence of the individual in the interest of the race. It becomes evident that the bee has not a loyalty towards the queen as such, but only to the future of the race as embodied in that queen. The worker is sacrificed to a perpetual chastity that only the race may live. One bee alone would perish,—she lives only in the midst of a multitude, laboring ceasely until she drops from sheer exhaustion. Her sting, which means her life, she uses rarely in self-defence, but primarily in race defence, with little or no thought of herself.

The swarming instinct is symbolic of race above individual. The bee will not forsake her fellows in distress, or even when misfortune befalls the royal family. In a colony, which for one reason or another, cannot weather the storm, we find the straggling few still clustered together in the "home" until the last one has paid with her life, an equal, indeed, of the most touching picture we can envision of a handful of shipwrecked sailors adrift on a raft, or a stranded group on a deserted isle. In the hour of need, the bee's loyalty to the clan is supreme. And yet she swarms and gladly forsakes her home at the very height of prosperity, and seeks a new abode in a new world—all for the

sake of that part of the race left behind. Says Maeterlinck in his classic, swarming is a "well considered sacrifice of the present generation in favor of the generation to come." Again he says that among men the social instinct "never gives rise to sacrifices as great, as unanimous, or as complete."

It is not strange, therefore, that philosophical minds should have drawn many lessons from the humble bee. Virgil, the Roman poet, at a time when Rome was gradually passing into a monarchy, very shrewdly points out that the bee teaches us:

First: The value of the Division of Labor, with its foreign service, its labor at home, its rearing and feeding of the young, and its ever alert sentinels at the door;

Second: The Community is Everything—for the majesty of the common law must ever prevail; and

Third: Submission to the Sovereign is absolute, a submission greater, he points out, than that of the Egyptians, the Parthians or the orientals, concluding that while the king is safe, all are of one mind.

In 1259, Thomas of Cantimpre, a Dominican monk, in his writings, compared the life of the bee with the life of the Christian. He pointed out that as a successful hive has one "king bee," so there should be one main Christian—namely the Pope. Other religious writers have held up the virgin workers, time and again, as examples of a cloistered community.

It may be of interest here that Swammerdam, in the 17th Century, making the first scientific dissection of the bee with the aid of a microscope, discovered that the queen was not a "king," as had been formerly believed.

Maeterlinck, again, in his meditating about the miraculous efficiency exemplified by the hive refers to the swarm as a "strange little republic." Other students have likewise gone to the bee as a source of intrigue, of industry, of organization, of cooperation, of socialism, of communism, and even the strategy of war, each preaching her virtues to serve his philosophy. It has even been hinted that we may have here a fertile field for some of the ideologies of present day Europe.

Touching a humorous note, we find a story in the folklore of the Hungarian peasants that God in his wisdom created the bee. The Devil, jealous of this achievement, tried to imitate this accomplishment—and created a wasp. Edward Step, in his *Marvels of Insect Life*, tells us, however, that the honeybee is no more industrious than its solitary relatives, the wasp, the bum-

blebee, and the rest, but that its storing of wax and honey has centered man's attention on it as something to eulogize—and rob.

And now a few words about the history of the honeybee, *Apis mellifica*, the variety most widely cultivated to-day. This insect is not native to North America. It appears to have been introduced into the New England area in or about 1638, and into Florida about 1763. Thence it slowly spread westward, reaching Kentucky by 1780 and the west shore of the Mississippi around 1797, at so nearly the same pace as the early white settlers and pioneers that the Indians called it the "white man's fly." To this day there is still among beemen an old belief that a swarm never goes eastward. It is of note that when John Eliot translated the Scriptures into the language of the North American Indians, he could find no words in their tongue to express the terms "wax" and "honey."

Yet through all these centuries man has never domesticated the bee, for no bee knows its human master. The bee specialists of the United States Department of Agriculture explain it thus: The queen and the drone have no real contact with the outside world, and hence no new experiences can pass along to the offspring. The workers, on the other hand, who face man's changing conditions, have no offspring. Hence the bee's life with man for 5,000 or 10,000 years has had no "domesticating effect." A wild swarm taken from a tree today is as docile tomorrow as any other colony. Likewise a swarm escaping today is as much at home in a hollow log or a rocky ledge tomorrow as were its ancestors thousands of years ago. Man has not domesticated—he has merely manipulated. And this by his knowledge of how a bee reacts in any given environment.

But shall it ever be thus? Can man and will man take this insect and reshape its bodily proportions and its life habits as he has done with the horse, the cow or the hen? Dr. Lloyd Watson of Alfred University in up state New York has given this angle a decade or more of attention. The mating of the queen and drone is indeed a selective process. The queen, who mates but once in her life, and then carries enough male germs in her body to fertilize from one to twenty-five million eggs, meets her lover high in the air. Since only the strongest and fleetest of perhaps thousands of rival drones receives this honor, vigor is assured in the offspring. Yet, Dr. Watson feels, though nature's breeding device is certainly selective, it is crude from

the law of probability basis. Furthermore, the bees of Arabia meet the bees of Arabia, those of Mexico those of Mexico, but rarely one another. Dr. Watson, hence, has been developing new strains by cross breeding. By inseminating the queens by hand, and using the semen from selected drones, he is attempting to bring together a number of desirous qualities. In these efforts he is using some 75 strains from all over the world. It is hoped that from a cross of the Carinolan, the gentlest of bees, and the Cyprian, a vigorous, hostile damsel, would develop an excellent honey-gatherer. The Saharan bee, for instance, has an unusually good strength of wing and a keen sense of smell, but is fidgety in its habits. The European Brown is less hardy, but possess habits far more dependable in the eyes of the beekeeper. There are varieties with longer tongues, long enough to enjoy our fields of red clover, and others with greater resistance to foul brood and other bee diseases. There are numerous stingless varieties in the tropics, but creatures whose storing tendencies because of eternal spring have been poorly developed.

Watson has found strains with larger pollen baskets, and others with larger honey storing stomachs. He tells us of breeds with a more fuzzy body, and of a Chinese variety willing to work at temperatures 10 degrees below where our Italian bee will remain active. Likewise he has found an almost endless variety of variable traits as regards quantity of wax and honey gathered in good, and in poor times, degrees of cleanliness, and tendencies to rob or to swarm.

And finally Watson raises this point: We know that bees depend on flowers. May we not likewise say that flowers depend on bees? Could not semi-desert crops and flowers grow in abundance in places now nearly barren, if the right bee strains were available?

Here surely, is a fertile field for a bee-loving Burbank!

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AMENDMENT PROPOSED

The change in the date of Thanksgiving during the last few years has created a problem. Section 1a of Article II of the By-Laws of the Central Association of Science and Mathematics Teachers states:

"Annual Meetings: The Annual Meeting shall be held on the second day after the last Thursday in November of each year."

Mr. Glenn Hewitt proposed the following amendment, which was approved by the Executive Committee. It will be printed in the two Journals previous to the 1941 Convention, and voted on at the time of the Convention.

"Time of Meetings: (a) Annual Business Meeting: The annual business meeting shall be held on the second day after the date proclaimed by the President of the United States as Thanksgiving Day of each year, or on such other date in November as the Board of Directors may prescribe."

A MATHEMATICAL APPROACH TO AESTHETICS

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Oswald Spengler, the late German philosopher, once wrote: "The mathematics of beauty and the beauty of mathematics are . . . inseparable."[1] The high school student, struggling with algebraic symbols, might wonder what he meant by "the beauty of mathematics" and the artist would protest at the phrase, "the mathematics of beauty." Almost anyone would have doubts about their inseparability even if he granted their existence. But, without going so far as to postulate the inseparability of mathematics and beauty, it has become possible in recent years to correlate mathematics and art to a remarkable degree in what is usually called aesthetic measurement.

Several preliminary remarks should be made before presenting an account of these attempts at aesthetic measurement. In the first place, it is obvious that, besides the mathematics involved in a satisfactory theory of aesthetic measurement, one must also expect to find a considerable amount of psychology and physiology.[2] Thus, while this article will deal almost entirely with the mathematical aspects of the theory, the psychological and physiological background should be kept in mind. Also we shall not undertake the task of sifting out quotations or remarks of either modern or ancient philosophers expressing the idea of unity of mathematics and art,[3] but shall begin with a discussion of the work of G. D. Birkhoff. Mr. Birkhoff states his problem as follows: "Many auditory and visual perceptions are accompanied by a certain intuitive feeling of value, which is clearly separable from sensuous, emotional, moral, or intellectual feeling . . . objects belonging to a definite class admit of direct intuitive comparison with respect to aesthetic value . . . To the extent that aesthetics is successful in its scientific aims, it must provide some rational basis for such intuitive comparisons."[4]

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[1] Oswald Spengler, *Decline of the West*, vol. I, p. 284.

[2] A lack of this might form a basis for criticism of some of the work discussed in this article.

[3] Some are: Plato's views on the "perfect triangle," Bertrand Russell's "Mathematics possesses not only truth, but supreme beauty . . . cold and austere, like that of sculpture," and the views of Spengler regarding the eternal union of mathematics and art in representing the various cultures that the world has known. (See bibliography.)

[4] G. D. Birkhoff, *Aesthetic Measure*, p. 3.

To begin with, he divides the aesthetic experience into three parts as follows:

(1) the effort of attention, which is determined by the complexity (C).

(2) the feeling of value, or aesthetic measure (M), which rewards the effort.

(3) the order (O) in the object, which seems necessary for M. Mr. Birkhoff then concludes that, roughly,

$$M = \frac{O}{C}$$

and gives a pseudo-mathematical argument to indicate its plausibility. (We might note that the formula corresponds to the artist's demand for "unity in variety.")

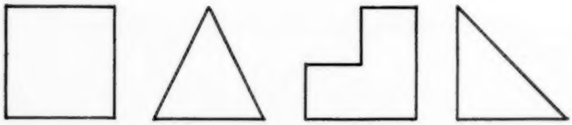
The next step is to analyze the composition of O and C, limited to his discussion of polygonal forms. Mr. Birkhoff also discusses music, poetry, and vases, but his discussion of polygonal forms is typical of his line of attack, and has the advantage of dealing with objects possessing fewer connotations than do music and poetry. (For obvious reasons, Mr. Birkhoff insists on the absence of connotations from the objects he analyzes.) We shall content ourselves with a rough statement of the composition of O and C, and then illustrate the use of the formula by means of a few examples. C, the complexity, is defined simply as the number of indefinitely extended straight lines containing all the sides of the polygon (for a convex polygon, simply the number of sides), while

$$O = V + E + R + HV - F$$

where, for example, V is a factor of vertical symmetry; $V = 1$ if the polygon possesses vertical symmetry, and $V = 0$ if it does not. E is a factor of equilibrium; $E = 0$ if there is unstable equilibrium, $E = 1$ if there is vertical symmetry, and $E = -1$ if the polygonal form *appears* to fall to one side. (Under certain conditions E may still be 1 even if there is no vertical symmetry.) Similarly, R is a factor of rotational symmetry and varies from 1 to 3; HV is a factor depending upon the relation of the figure to a horizontal and vertical network of lines, and varies from 0 to 2. Finally, F is a "dumping ground" for such unfavorable effects as ambiguity of form (as, for instance, in the case when the figure is not quite an isosceles triangle, or there is too small an

angle between non-parallel sides, etc.), and varies from 0 to 2.

We conclude our discussion of Birkhoff's work with a few examples:[5]



The square, which rated the highest in the ninety polygonal forms tested by Birkhoff (the ratings ranging from 1.5 to -0.17), has $C=4$, $O=6$. The individual parts of O are: $V=1$, $E=1$, $R=2$, $HV=2$, $F=0$. For the equilateral triangle, $C=3$, $O=3.5$. The individual parts of O are: $V=1$, $E=1$, $R=1.5$, $HV=0$, $F=0$. For the third figure, $C=6$, $O=1$. The individual parts of O are: $V=0$, $E=1$, $R=0$, $HV=2$, $F=2$. Finally, for the right triangle, $C=3$, $O=0$. The individual parts of O are: $V=0$, $E=1$, $R=0$, $HV=0$, $F=1$.

It should be noted that while Birkhoff claims to have found "satisfactory" agreement between the ratings obtained by his formula and the judgment of students in two graduate courses held at Columbia University (summer 1929) and Harvard (summer 1930), several psychologists have made tests, the results of which are not always in agreement with Birkhoff's results. Thus Davis[6] finds, in the testing of ten of Birkhoff's polygons, almost no correlation between the experimental order ratings and the Birkhoff ratings, and concludes that, "for the polygons, there is . . . no support for the formula, either a priori or empirically." But Beebe-Center and Pratt,[7] on the other hand, find that the mean agreement between the formulas and observers was a little better than average, and conclude (also with respect to Birkhoff's formulas in connection with poetry, music, and vases) that it is possible to regard Birkhoff's measure as accomplishing a good deal of that which its author intended to accomplish. It is also true that the work of Davis is of doubtful value, for he does not caution his subjects to discredit connotation effects as far as possible (as, for instance, in the cross and the swastika—two of the polygonal forms listed

[5] *Ibid.*, plates II to VI.

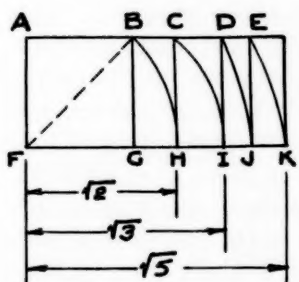
[6] R. C. Davis, "An Evaluation and Test of Birkhoff's Aesthetic Measure Formula," *Journal of General Psychology*, 1936, 15, pp. 231–240.

[7] J. G. Beebe-Center and C. C. Pratt, "A Test of Birkhoff's Aesthetic Measure," *op. cit.*, 1937, 17, pp. 339–353.

by Birkhoff), and furthermore allowed them to examine the polygonal forms in other than the positions that Birkhoff describes (i.e., they may have examined the forms by rotating them 90° from Birkhoff's positions). This last procedure Davis attempts to justify by claiming that there is no part of Birkhoff's proof which depends on the vertical position of the object, but it is obvious that both V (vertical symmetry) and E (equilibrium) are dependent on the vertical position, and may change if the polygonal form is rotated in any way from its original position.

Finally, between the results of Rashevsky (described later) and those of Birkhoff, we find a serious divergence.

Somewhat allied to Birkhoff's work is the work of J. Hambidge[8] on the analysis of Greek vases. The essential part of Hambidge's theory is his conclusion that the outstanding characteristic of the Greek vase maker (as compared, say, to the Roman or Egyptian) is his tendency to make the various parts of his vase in irrational rather than rational ratios. For example, the Nolan Amphora[9] at the Fogg Museum in Boston was found by careful measurement to have a ratio of 1.7071 $(1+\sqrt{2}/2)$ between its greatest width and its height. Mr. Hambidge goes further, however, and introduces what he calls "dynamic symmetry." Thus he finds in a geometrical analysis of any one of hundreds of Greek vases such figures as "root-2," "root-3," and "root-5" rectangles, and, picturesquely, "the rectangle of the whirling squares." His root rectangles are defined as follows:

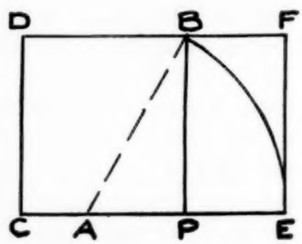


ABGF is a unit square. *BH* is an arc of radius *FB; CI* is an arc of radius *FC*, etc. Then *ACHF* is a root-2 rectangle. *ADIF* is a root-3 rectangle, etc. Now consider the figure on the next page:

[8] Jay Hambidge, *Dynamic Symmetry*.

[9] *Ibid*., p. 45.

in which $DBPC$ is a unit square, $CA = AP$, and BE is an arc with radius AB. Then $DFEC$ is known as the rectangle of the whirling squares. In a further discussion, Mr. Hambidge explains the reason for his choice of the name "whirling square rectangle" and shows how it fits into his analysis of Greek vases, and (rather strangely) into a geometric representation of a logarith-



mic spiral (defined by $\rho = ke^{c\theta}$), a form frequently found in nature (as in shells and in the orderly distribution of leaves of plants).

It is interesting to note, in concluding this brief description of Hambidge's work, that several American artists[10] have won prizes with, and sold for handsome sums, paintings which were planned dynamically symmetric according to Hambidge's theories.[11]

In marked contrast to the work of Birkhoff and Hambidge stands the work of the mathematical bio-physicist, Nicolas Rashevsky.[12] As yet he has accomplished no such "precise" formulations as have Birkhoff and Hambidge, but will, no doubt, together with his co-workers in the field, eventually give us the most important and complete theory of aesthetic measurement. One of the reasons for the greater possibilities in the bio-physicist's attack is his dependence upon the observer only, and not the thing he observes. Thus his theories may be modified, without much trouble, to conform to new discoveries regarding the mechanism of perception. His general line of attack, as for example in the case of Birkhoff's polygonal forms, is to calculate the total amount of excitation of neurons resulting from the eye's following of a given polygonal contour. Then, if this total amount of excitation be transmitted to a "center"

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[10] As Bellows, Christine Herter, and Howard Gils.

[11] Somewhat allied to this latter aspect of Hambidge's work is the work of the artist and designer, Claude Bragdon (see bibliography). It is also true, of course, that many designers in the field of industrial art today make liberal use of elementary mathematics in their work.

[12] Nicolas Rashevsky, *Advances and Applications of Mathematical Biology*, chap. XII.

whose excitation in turn produces a sensation of pleasure, one can consider the intensity as a measure of the aesthetic value of the polygon. In spite of the importance of Rashevsky's work, however, it is not feasible in an article of this type to give any more than this brief indication of his methods, because of their dependence upon the general principles of mathematical biophysics, an exposition of which is far beyond the scope of any single article.

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MOST ENERGETIC PARTICLES MANUFACTURED

Atomic bullets as powerful as some of the cosmic rays and the most energetic man has ever produced—96,000,000 electron volts—have been manufactured with the University of California 225-ton cyclotron, Dr. Ernest O. Lawrence, Nobelist, made known at the University of Chicago Fiftieth Anniversary Celebration.

This is six times the highest energy previously achieved, that of deuterons (heavy hydrogen) at the same maximum speed.

With carbon bullets Dr. Lawrence expects to be able to take six steps up the atomic ladder in transmuting elements. If iron were bombarded it would become arsenic.

With the giant new cyclotron now building at Berkeley, carbon bullets of 600,000,000 electron volts will be possible.

The research accelerating carbon atoms from carbon dioxide gas was done by Dr. Emilio Segre and Cornelius Tobias in the University of California Radiation Laboratory.

TEMPERATURE CHANGES IN PONDS

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A girl in one of my classes came to me regarding the term problem upon which she was working. "I don't understand it," she complained, "Yesterday, the water at the bottom of our pond was warmer than the water at the top. I took several readings but I always had the same results."

One could sympathize with her bewilderment. In her high school science courses and in her science texts, there had been ample emphasis upon the stratosphere and upon the ocean depths, but little upon the prosaic subject of ponds.

Yet ponds are a part of our immediate environment, and they are certainly much more available for study than are many of the subjects included in science courses. Also the principles involved in the temperature changes of pond water are unquestionably important. The phenomenon mentioned above is one that has great significance to us, so great indeed, that life as we know it might never had been possible otherwise.

The study of these principles requires no unusual opportunities and no elaborate apparatus or techniques. Every ice-pond, out-door swimming pool, or even a mud-hole presents a whole series of problems.

The apparatus may be readily improvized. Although girls are not thought of as being mechanically ingenious, the girl referred to above devised an excellent water sampler from a four-quart milk-can weighed down with stones and containing a thermometer. She used one cord to lower the can to the desired level and another cord to raise the cover slightly to let water in.

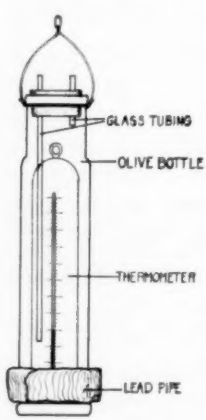

FIG. 1. A water sampler for determining the temperature of subsurface water.

The writer has used the device shown in Figure 1, and has checked the readings against an expensive deep-water thermometer. As can be seen, some water enters as soon as the bottle is submerged. If dropped quickly, however, the readings are but slightly affected. If desired, one of the glass tubes may be tapered in a flame to reduce the speed of filling.

Figure 2 shows in graphic form the data taken by the girl for a small pond near Cortland, New York. When she took her first readings, the surface water was warmer than the bottom water. Then, during the week of November 10–17, a cold wave cooled the water markedly. It was during this week that occurred the curious inversion of temperature layers.

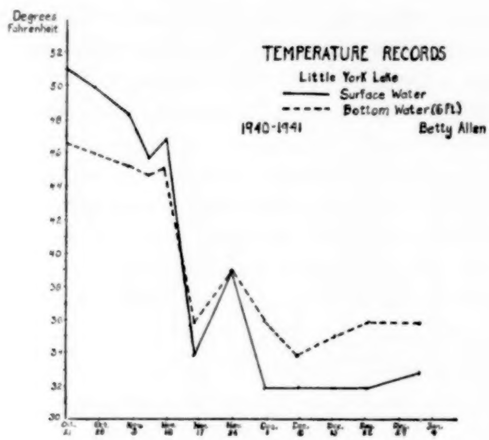

FIG. 2. Temperature records taken by a physics student as part of a term problem.

By interpolation, we see that the inversion took place when the water had cooled to about 39°F. Apparently, if the above data are at all correct, the density of water fails to change regularly with the temperature.

Physicists have discovered that the behavior of cooling water is not regular when it nears the freezing point, and they have determined the volume-temperature curve shown in Figure 3. This curve indicates that liquid water attains its maximum density at about 39°F.

This property markedly affects the cooling and warming of ponds. In early autumn, as the surface water cools, convection currents are set up and warmer subsurface waters are forced up to be cooled in their turn. Once the pond water has cooled to 39°F., however, convection must cease. Further cooling at the surface reduces the density and the cooled water tends to remain at the top. Subsurface waters must then cool largely by radiation and conduction through the upper layers.

In the spring, surface water becomes heavier as it warms to

39°F. Thus, limited convection occurs in the upper layers of the pond while the temperature is rising to 39°F.; above this temperature, the surface water becomes lighter and convection ceases.

Convection is a rapid process, as swimmers usually discover when they try the water after a few days of cool weather. Conduction and radiation, on the other hand, are slow processes in water. Consequently, the bottom water in deep lakes is little affected by either summer heat or winter cold, and remains at 39°F. the year round.

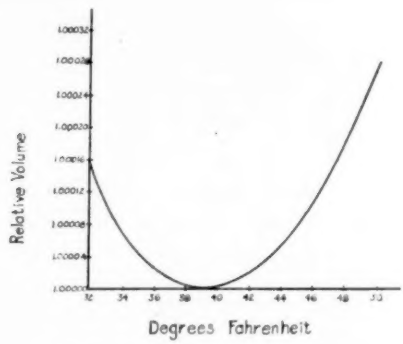

FIG. 3. Volume-temperature curve of water showing behavior near the freezing point.

Thus we see that ponds and lakes tend to be thermally stable. When they warm above or cool below 39°F. it is by slow conduction and radiation. When they return toward the 39° temperature, the rapid process of convection also becomes involved.

Two other factors tend to keep bodies of water thermally stable. Water has the highest specific heat of any natural substance. In other words, before water can drop one degree in temperature it must lose a great deal of heat; similarly, before it can rise one degree, it must be supplied a great deal of heat. Water also has high latent heats of vaporization and fusion. In summer, increased evaporation requires much heat and the pond or lake is cooled by the process. In winter, formation of ice releases heat and thus the cooling of the water is checked. In addition, once the ice cover is formed, radiation is reduced, and any snow blanket effectively reduces both radiation and conduction.

Wind is a very important factor, perhaps more important than convection, in bringing about the mixing of the top and

bottom waters of a pond. The effect of wind-mixing, however, is greatly affected by the density gradient of the water. In spring and autumn, when all the water has about the same temperature, and consequently the same density, winds can thoroughly mix the top and bottom waters of a pond. In the summer, however, the marked difference in densities at the top and bottom, limits the effect of the wind to the surface layers of approximately the same temperature. To a lesser extent, the same is true in winter before the ice forms; afterwards, of course, the ice cover prevents wind-induced circulation.

One needs but little imagination to realize the importance of the curious little twist in the temperature-density curve of water. Were water to contract regularly while cooling, convection would rapidly lower temperatures to the freezing point and cause the ponds to freeze from the bottom up. Melting during the summer would be brought about largely by conduction. Since water can be boiled in the top of a test tube while ice remains at the bottom, it is probable that large lakes would contain ice the year around. Aquatic life would be nearly impossible and land life would have to be much altered to meet these conditions.

It seems, therefore, that this topic is worthy of consideration in high school science. One or two field trips serve to establish the problem. Simple experiments acquaint the pupils with some of the properties of water. Reading brings to the pupils some of the discoveries that others have made in the same field.

As to whether this topic should be considered in high school biology or in high school physics is a matter meriting little discussion. It belongs in both subjects but defies compartmentalization. It brings about an appreciation of some of the interactions that take place between the physical and the biological environments. Both physics and biology are much in need of the broader interpretations that this topic provides.

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This Nation will survive, this State will prosper, the orderly business of life will go forward if only men can speak in whatever way given them to utter what their hearts hold—by voice, by posted card, by letter or by press. Reason never has failed men. Only force and oppression have made the wrecks in the world.—William Allen White.

DETERMINATION OF DEW-POINT

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A simple form of Regnault's method for obtaining the dew-point has been in common use in elementary work. By means of a rubber bulb air is forced through ether contained in a small polished metal cup and the temperature at which condensation appears on the polished surface is noted.

Because the release of ether fumes into the air is sometimes objectionable and because the proximity of the operator's hand and person may introduce appreciable errors it is possible to

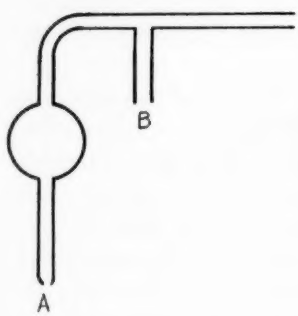

Fig. 1. Detail of glass tube.

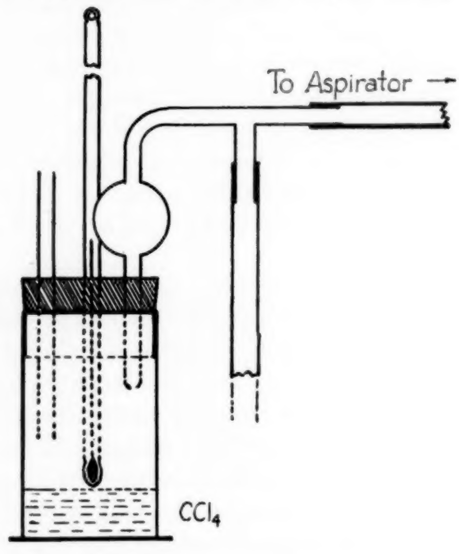

Fig. 2. Dew-point apparatus.

modify the above method to obviate both objections and at the same time to greatly increase the accuracy of the dew-point determination.

The bulb forcing air through the liquid is replaced by a rubber tube leading to an aspirator. This *draws* air from the room through the evaporating liquid. A second rubber tube attached to the water outlet of the aspirator is directed down into the drain. This prevents very effectively the release of fumes into the air. Carbon tetrachloride is effective in producing temperatures to minus 4°C. Its use is less objectionable than that of

ether. On exceptional days it may be necessary to use ether.

The diagram should make the entire procedure clear and save a lengthy description. Figure *1* is a glass tube with a side neck fused to it. The bulb blown in the tube serves (partially at least) to prevent the liquid from being drawn into the rubber tube leading to the aspirator. Opening *A* should be smaller than opening *B*. Figure *2* shows the entire assembly ready for use. A rubber tube three feet long is attached to the side neck. This allows the air to be by-passed or drawn through the liquid in the polished cup by releasing or pinching the tube. The flow of water through the aspirator when once properly adjusted may be left undisturbed throughout the experiment and the appearance and disappearance of condensation on the cup controlled entirely by manipulating the rubber tube attached to the side neck. The stopper used in the cup must be a cork stopper since both carbon tetrachloride and ether will attack rubber. The rubber tube connecting the dew-point apparatus and aspirator need not be heavy walled since the system is open to the air and no vacuum is produced. Distances between aspirator and cup up to thirty feet have been tried in the writer's classes. Numerous trials by members of the classes over a two-year period of time have shown that the dew-point is easily and rapidly determined and that the temperature difference between appearance and disappearance of the moisture on the polished surface is controllable to within one degree Centigrade. A polished cup having a comparison surface is helpful.

FIND WHY FATAL PNEUMONIA STARTS WITH SEVERE CHILL

George Washington had a severe chill before he died of pneumonia. That was over a hundred years ago.

Today physicians know why fatal pneumonia often starts that way. Prof. Oswald H. Robertson of the University of Chicago explained the reason to the University of Chicago's 50th Anniversary Celebration.

Chilling of the body surface, Prof. Robertson said, causes a slight contraction of the epiglottis, the lid-like valve that closes the upper end of the windpipe during swallowing and prevents food particles and liquids from going down your "Sunday throat." With this vital valve reduced to a poor fit, fluids from the nose, mouth and upper part of the throat can get down into the lungs, carrying with them pneumonia germs that have accumulated in those entryways to the outer world. If there is an irritated condition in the lungs, as from a cough already started pneumonia is likely to follow.

SCIENCE SERVING COMMUNITY NEEDS

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Central High School, Tulsa, Oklahoma

In a previous article (see School Science and Mathematics for December, 1940) I discussed the subject, "Science Serving the Student." At this time I wish to call attention to some of the contributions which a properly organized science program should make to the community in which the school is located.

If we will but study the science needs of the community in which we live, we shall find that there is much scientific knowledge available that if used would make it possible for the people of the community to live more successful and happy lives. A careful survey of the primary and secondary industries of the community will show we may better fit our students to live in this scientific age.

Such a community survey was made in Birmingham, Alabama, by the teachers of the school system assisted by their students. This report was published and proved to be valuable information of how to make the schools fit the needs of the community.

While we live in a so-called scientific age, we do not live scientifically. We are very inefficient. The people perish for lack of knowledge as well as the failure to use the available knowledge. The preventable sickness causes great loss of time and money and needless suffering. We are the most wasteful nation on earth. The conservation of our great national resources is therefore of prime importance in any science curriculum. If we continue to waste our national heritage, future generations will not rise up and call us blessed. There is enough scientific knowledge to make every workman efficient in his task but this knowledge is not known by the workman and he must labor for that which is not bread. These needs are a challenge to teachers of natural science courses in our high schools who see the problem and are trying to solve it.

While there is a general agreement as to the general objectives, the real difficulty comes when we try to arrange the scientific knowledge so that it will become a vital part of the science curriculum. I wish to present one approach to the whole problem which became the center of a course in Geography in high school which I organized and taught a few years ago. All science courses could not use the same approach but this out-

line may be suggestive to emphasize a point of view. The course was arranged around the fundamental human needs.

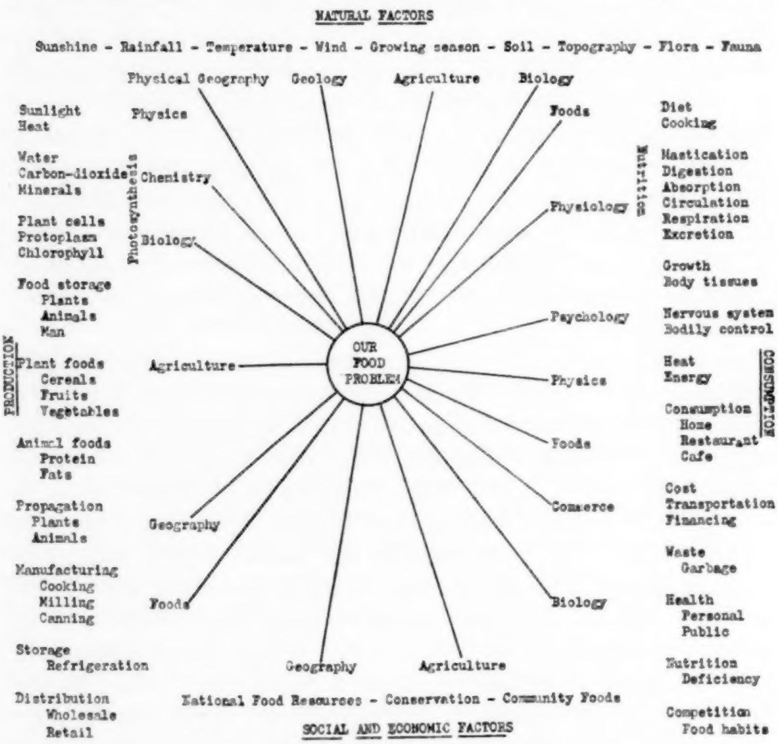
What are these fundamental human needs and how may science serve them? Our needs are about the same for every community, the need for food, clothing, shelter, power, transportation, communication and many social and spiritual needs which are partly scientific but which are usually classed under social science.

While every community has these same needs and must solve its own needs, these are directly or indirectly related to every other community of the nation and to other nations as well. A complete understanding of our local needs and problems will show that they are world-wide. Our health, social, moral, family, and leisure problems must be solved locally but the way we solve them affects every other community. The European War is now affecting all of us, and so will the problems of reconstruction, when it comes, affect all of us. We cannot live unto ourselves and we cannot even die unto ourselves. Thus our local problems are world problems and our local needs are world needs.

An understanding of the climates in the community will take into account the world wind belts, the temperature belts, the rain which is affected by bodies of water, winds, mountains, and other factors, the sunshine, the length of day, and the change of seasons all of which are determined by world movements in relation to the sun and moon. Our food problems are related to these climatic factors as well as soil factors which are determined ultimately by the climate. Our food problems are related to other communities, to transportation, communication, finance, custom, religion, and history. It is a most interesting exercise to see how many courses in high school relate to our food or our clothing or shelter. These are not studied exclusively in the home economics courses in high school.

In our Geography course we began with the study of our food problem. What are our most important foods? What is the source of our bread? Where are the wheat belts of the world? What climates determine the wheat belt? What are the manufacturing processes which must be done before the bread reaches us? What are the kinds of meat available in the local community? Where are these produced? What manufacturing processes are necessary? What meat products are now produced locally? How do those products produced elsewhere reach us? And so

with our study of fruits, vegetables, cereals, sugar, fats, condiments, drinks, confections, and other food products. The exercise took some students on individual or group trips to the butcher shop, fish market, bakery, flour mill, grocery store, wholesale house, farmer's market, dairy, ice-cream factory, packing house, and other trips. These trips were made at the request of students who wished to learn more about their food sources. Some study was made of the relative costs of food, and the factors that enter into the cost such as transportation,

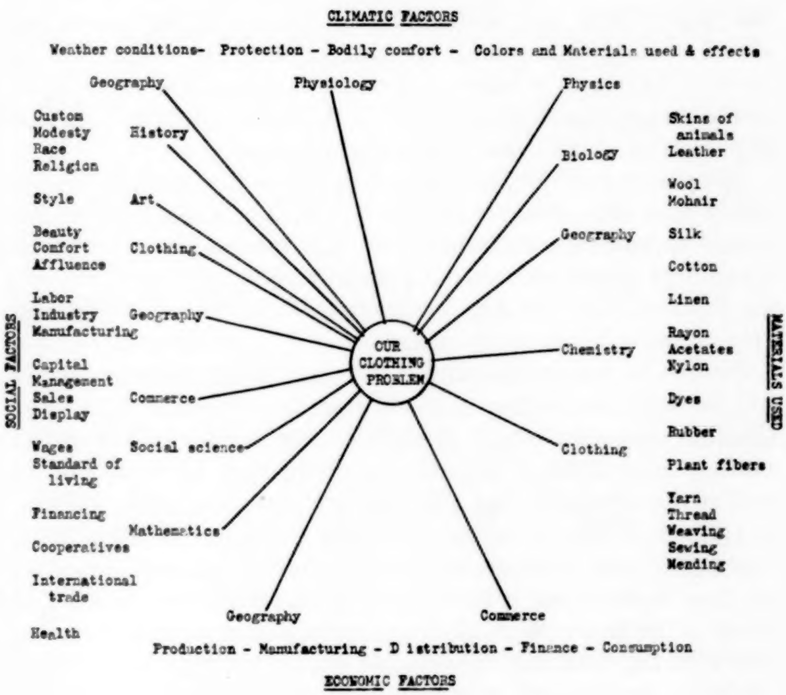


refrigeration, manufacturing, financing, and labor. Some of the foods that are produced elsewhere could be as well or better produced at home and thus furnish labor for home industry.

The food of other lands became the basis of study of these lands and countries. Many of the movements of peoples have been in search of food—better sources of food. Many of the wars of the world have been fought directly or indirectly because of food needs of peoples and nations. The present war in Europe is a good example of how food or a lack of it may influence a war,

even determine the result. "Food will win the war" was one of our slogans of the first World War and had much to do with winning it on our part and losing it on the part of the Central Powers.

The series of diagrammatic presentations of these fundamental human needs will serve to show their relationships to the various courses offered in high school. **Our food problem** is given first. The natural factors are placed on one side and the social and economic factors on the opposite side. Production is placed



opposite to consumption. Photosynthesis becomes a part of production and nutrition is a part of consumption. The high school subjects that have anything to do with our food problem are listed somewhat in the place they make a particular contribution. This is the first of the health series and perhaps the most important.

The second problem studied was **our clothing problem**. What are our clothing materials? Where is our cotton produced? What climatic factors are involved? A trip to the cotton mill was made

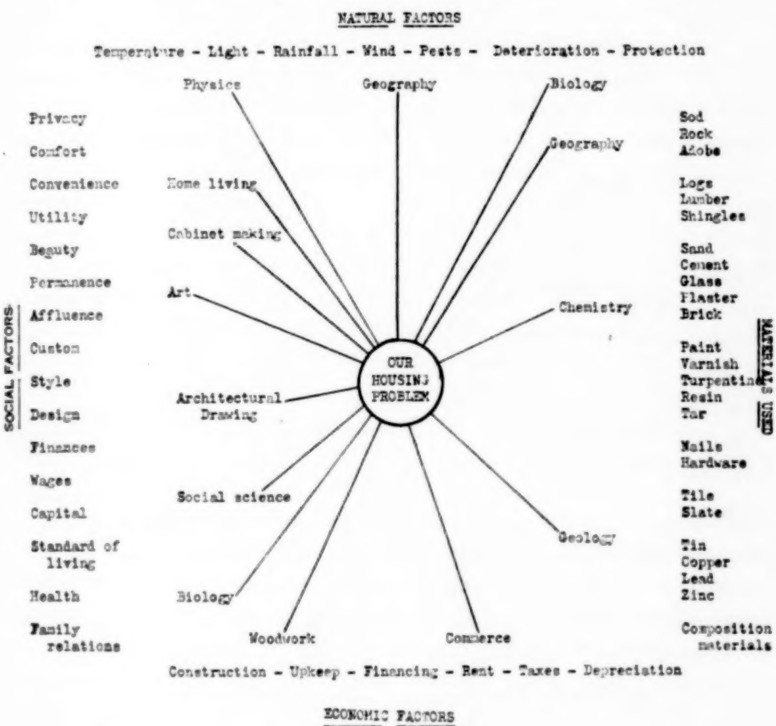
by a group of the class. The various steps in the making of cloth were studied by moving pictures of the cotton mill. The movies also brought us the linen industry, silk industry, tanning of leather, wool, making of shoes, rayon manufacture, and other industries connected with our clothing problem. What is produced in the local community? Why is New York City the center of the clothing manufacture in the United States? Why is Paterson, N. J., the center of the silk industry? Why is Lawrence, Mass., the center of the woolen manufacturing? What difference is there in the cotton manufacturing of the South and the North? Why are Boston and St. Louis competitors in the shoe industry? The sale of clothing in the local community is divided into various kinds of stores and shops. The cleaning of clothes is an important industry as shown by the laundries and dry-cleaning shops. Shoe repair is also important.

The diagram of our clothing problem has the climatic factors above and the economic factors below. The social factors are placed opposite the materials used. It is interesting to note how many high school courses have something to do with our clothing problem. Manual Arts has a contribution as has chemistry. Dry-cleaning is now so specialized that it is necessary to employ a chemist of highly specialized training or some of the fabrics will be destroyed rather than cleaned. In one of our local dry-cleaning shops a German chemist is employed who knows the various dyes, natural and artifical cloths that are now used as well as the chemicals that will remove the various kinds of spots. A trained Bulgarian is the dyer and the tailor is from Italy. Our high school graduate must be content with being the delivery boy as he is not sufficiently trained for the special kind of work in the plant. With all the modern acetates, rayons, nylon, and with the dyes and the possible stains that may be found on clothing, a specialist is required or the clothing will not be cleaned but rather ruined.

Our housing problem is the third one studied. What materials are used for building? Why are these used? Where are they secured? How do these building materials differ in different communities, in different climates, and in different countries? A visit to a local lumber yard will show the different kinds of lumber, and the uses of these in the building of a home can be explained. A visit to a brick plant, cement manufacturing industry, marble works, plumbing shop, paint store, or other place of business that has to do with our homes is always profit-

able and will show how many industries have to do with our housing problem.

How can we improve the housing in this community? How could we improve our own homes? How can we make the home and community more beautiful and attractive by landscaping, by parks, by places of beauty and amusement? How can we improve the lighting of our homes may be studied in physics, as well as the better use of electrical appliances. In chemistry we can learn about paints, varnishes, plasters, composition



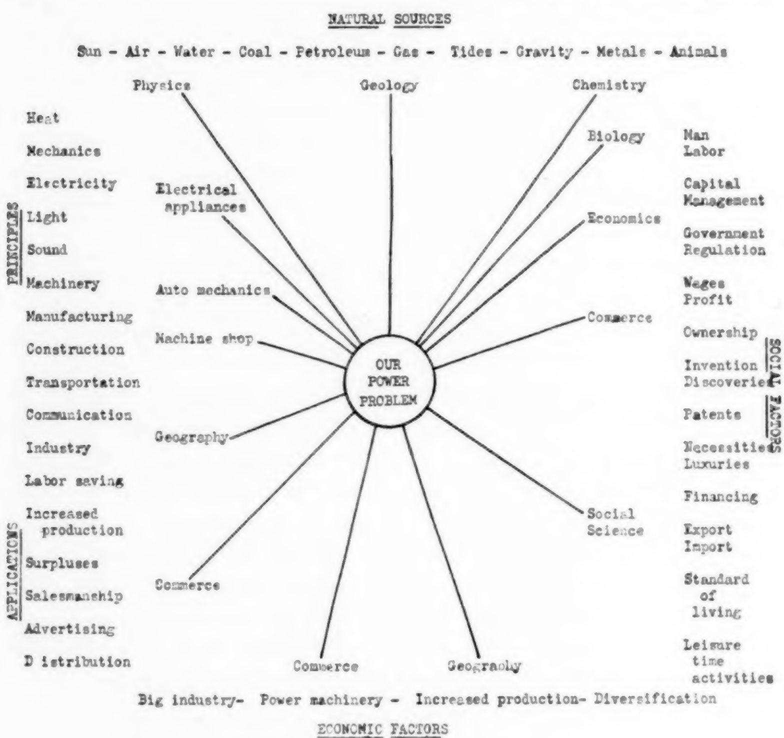
woods, deterioration and its prevention, and many other housing problems and needs.

We are becoming more housing conscious as a nation. With the statement that one third of our nation is ill-housed, ill-fed, and ill-clothed, it is time we gave more attention to this important problem. While many high school courses may relate to these problems, the important thing to do is to emphasize these in the classroom.

In the diagram of our housing problem, natural factors are

placed opposite economic actors and social factors are placed opposite materials used. The various courses in high school that may in any way contribute to the objectives listed are given in the inside and are connected by lines to the central problem.

Our power problem is considered next. In this machine age the nation with coal and iron can build a war machine and thus conquer and control the nation or peoples without this coal and iron. Man and the machine make possible our modern power



manufacturing and thus bring us a higher standard of living. It is estimated that each person in the United States has the equal of 300 servants or slaves working for him. These servants are the coal, oil, gas, and water-power driving the machines of this nation day and night, week in and week out, year in and year out. We push the button to turn on the light, turn the faucet to bring our water, open the gas jet to give us our heat, ring the telephone to have our food delivered, turn the switch, step on the starter and the gas to take us to the office or workshop,

and then do our work with power tools far more accurately and faster than the hand of man could possibly do it. We have increased the production of labor at the same time reducing the hours of labor by our use of mechanical power.

In the diagram showing our power problem, natural sources of power are placed opposite economic factors. Applications and principles are placed opposite the social factors. There are many courses in high school that are directly or indirectly related to power besides physics and geography. Our standard of living and leisure time activities depend on the use of power by the laborers who produce our necessities and luxuries. These are made possible by inventions and discoveries in the field of science. By securing patents on these inventions and discoveries we can organize industry to thus produce our necessities and luxuries. We may have a surplus to export and must import raw materials needed.

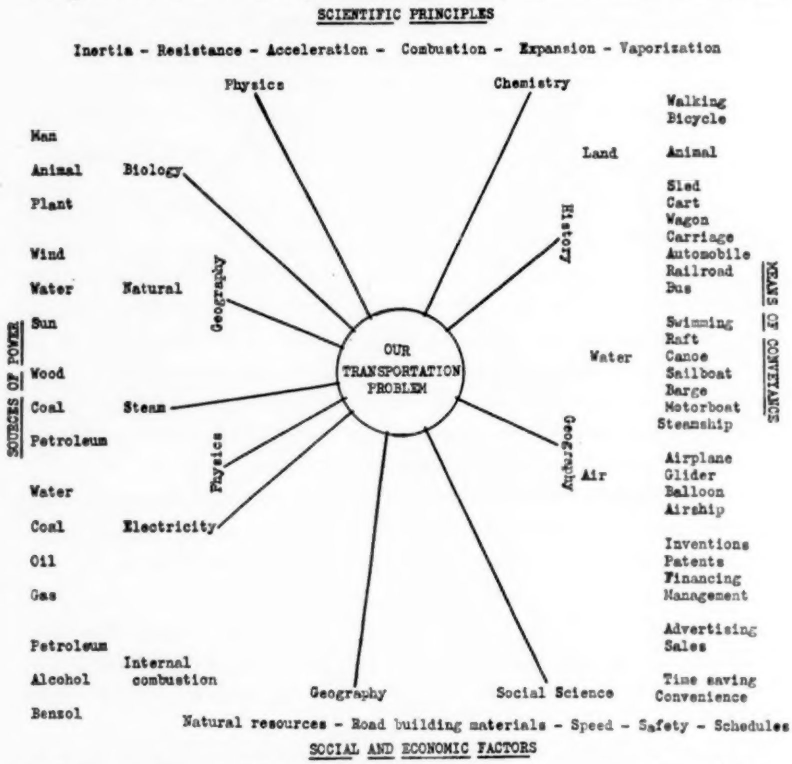
The applications of power result in the manufacturing plants which must be constructed, and they then produce the means of transportation and communication needed in the industry. The labor saving results in higher production which produces a surplus which must be advertised and sold. The distribution of these products is the final result. Under the economic factors as shown in the diagram we have big business and industry which uses power machinery for increased production and it all results in diversification and specialization.

Our transportation problem is next considered. In every community transportation is directly related to every other problem. By means of transportation on land, on water, or in the air, we have brought to us the products from all parts of the earth for our food, clothing, shelter, leisure, and other needs. A study of the local transportation schedules by train, bus, airplane, or boat will show how every community is tied to every other community of the State, Nation, or the world.

In our diagram we begin with scientific principles such as inertia, resistance, and acceleration which belong to physics and then we note combustion, expansion, vaporization which belong to either physics or chemistry. The sources of power for transportation may be from man, animal, or plant and thus belong to biology or it may be coal, oil, or water and belong to geology. The power may be natural or be produced by steam or transformed into electricity. The engine may be an internal combustion one driven by gasoline or Diesel motor oil.

On the opposite side of the diagram are listed the various means of conveyance on land, water, or in the air somewhat in the order of their discovery or invention. Among our social and economic factors will be noted safety which has become such an important factor with our speed brought about by the automobile.

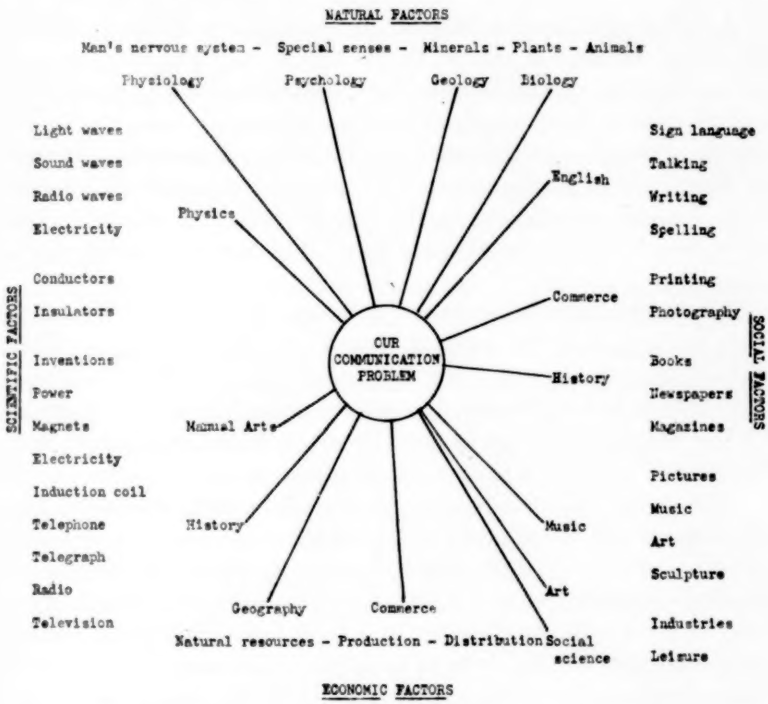
Our communication problem is the last one shown in this series of diagrams. The world has become a great community with our daily newspaper, the Associated Press, the radio, which bring to us news—local, state, national, and international. All



of these make possible propaganda for peace or war, for religion or advertising, for amusement or education, for good or bad.

The natural factors begin with man's nervous system and special senses. The scientific factors begin with light and sound waves. The social factors begin with language, which may be sign, spoken, or written. The economic factors begin with natural resources which become the materials out of which our communication must be built.

A careful study of these diagrams will show many important omissions. This graphic presentation of the relationships of science is intended to show how the various courses in high school may contribute to our fundamental human needs. As the community supports the school, so the school should serve



the community needs And thus we can hand down to the coming generation the great scientific heritage so that our lives may be the more successful economically, physically, mentally, and spiritually.

UNCLE SAM NEEDS SCIENTISTS TRAINED IN RADIO AND SOUND

Uncle Sam is on the search for scientists who have had at least a four-year college course, including major courses in physics, especially radio and sound. The Civil Service Commission has just announced that it will receive applications for $2000 per year positions for junior physicists. Candidates will not have to take a written examination, but will be rated on education and experience.

THE TEACHING OF THE SCIENTIFIC ATTITUDE BY MEANS OF SELECTED TOPICS IN PHYSICS

PHYSICS SYLLABUS COMMITTEE
Physics Club of New York

A syllabus is useful only in so far as it is instrumental in realizing the aims it sets forth. As teachers of physics, we wish to see certain desirable outcomes. "True learning is regarded not as ground covered or knowledge gained but as adaptations which take effect in the behavior of the pupil, such as a change in the attitude or the acquisition of a special ability." (Reference 1.) These outcomes in the pupil's behavior must serve as the guide by which we include or exclude material in the syllabus.

A syllabus committee of the Physics Club of New York has been investigating the present New York State physics syllabus with respect to its adequacy in connection with the above aim. This article is a summary of a report presented to the Club.

The committee believes that these changes in the pupil may be divided into three categories. (Reference 2.)

1. A development in the pupil of the scientific attitude and a training in the value and use of scientific method. Our present syllabus states: "Most important of all, the pupil should be started along the road to a scientific habit of mind, with inspection of data and conclusions, and with the development of intellectual honesty and love of truth that will carry over into his future judgments in all subjects of life." However, while the syllabus suggests, "For the present, it is probably best that this higher side of science teaching should be brought in, not formally, but only in the incidental manner," we believe that this higher side of physics should be brought in formally and directly. We believe that the realization of this aim will occur only in so far as we focus the pupils' and our own attention upon this aim. The present lack of scientific attitudes in our pupils shows the need of the more direct approach. (Reference 3.)

2. An understanding of the great generalizations in physics. These basic generalizations, underlying all branches of physics, are to be so developed that the student may acquire a coherent world picture and grasp the essential unity of physics.

3. An understanding of the applications of physics in his daily environment. The student should acquire an intelligent

appreciation of the dependence of the modern world upon science and scientists.

The committee is dividing its work into three major parts;

1. Surveying all branches of physics, either in or out of the present syllabus, which could be used most effectively to develop the scientific attitude.
2. Listing the great generalizations to be understood by the pupil.
3. Listing in detail the pupils' experiences which may be better understood by a knowledge of physics.

This report deals only with our work on the first of these, which the committee considers to be the most important as well as the most difficult phase of the work. The committee is eager for suggestions and criticisms of this report.

The committee proposes the following major understandings to be mastered by the pupils for the development of scientific attitude and a training in the value and use of scientific method.

A. A fact is a carefully checked observation. Inferences and theories derived from these facts may be completely wrong.

B. Material effects are due to definite causes; by knowing causes, effects may be predicted.

C. Generalizations to be sound must be based upon

1. Adequate and sufficiently large sampling of facts.
2. Use of facts within experimental limits.

D. One must develop an open mind to newly discovered facts and be willing to revise one's opinions accordingly.

The committee surveyed the field of physics for topics which it felt could be used most effectively in teaching these understandings. The topics may be developed as laboratory exercises, class demonstrations, discussions or projects. The time needed may vary from a part of a period to a series of lessons with one of these topics as the core. Experimentation in classroom situations is necessary for final decision as to the most effective method of presentation. In all cases the teaching is to be so directed as to stress the scientific attitude as the primary aim. This does not preclude the further use of the topic for content development.

The development of the scientific attitude in physics is, however, only the first step. The attitude should be given expression and practice in daily life. Application to advertising, consumer education, etc., should be made in the physics class.

The following is an abridged list of typical experiences and

lessons that lend themselves to the development of these understandings.

A. A fact is a carefully checked observation. Inferences and theories derived from these facts may be completely wrong.

1. Inferences from observations made by the eye are often wrong.

a. A boy sights along the top of a ruler towards a coin in a tank of water. The inference that the coin is where it seems to be is easily disproved by sliding a ruler down the line of sight.

b. A coin hidden in a cup may be brought into view by filling the cup with water. A stick may be made to appear broken by half immersing it in water.

c. Arrange a lighted candle, jar of water, and a pane of glass so that the candle seems to burn under water.

d. Create the illusion of a flower in a vase or an electric bulb in a socket by the use of a concave mirror.

e. Show the effect of optical illusions on judgment of size and direction of lines. Discuss the practical uses of optical illusions in slimming lines in dresses, deceptive packaging, camouflage, and color contrast for visibility.

2. The inferences drawn from attempts to use the skin as a thermometer are sometimes wrong.

a. The relative temperatures of blocks of iron, wood, copper, etc., may be judged by students touching them. The inferences may then be checked by measuring each block's temperature by thermometers inserted in them.

b. Temperature inferences as given by body sensations may be affected by previous conditions. A boy whose hands have been in hot water will report a different temperature for lukewarm water, than a boy whose hands have previously been in cold water.

3. When students are shown a uniform lever balanced upon a pivot, their inference may be that the lever is balanced because both sides of the stick weigh the same. To show that the inference in this case is correct, cut the lever at the pivot and weigh both pieces. Now balance a spoon upon the finger and by cutting this at the point of balance, show that the two halves are not of equal weight. Balance a weighted object so that the class may clearly see that the pivot need not divide a balanced object into two parts equal in weight.

4. Because of their training in arithmetic, students carry over

into physics the inference that physical quantities may be added in the same manner as numbers. The inference that two pounds and two pounds combine to always equal four pounds will be dispelled by experiments in composition and resolution of forces.

5. In the study of the dry cell, the question may be raised as to the reason for building large and small cells. Inferences as to effects of the size upon voltage and current may be made and checked.

6. A study of proposed perpetual motion machines may be used to show that incomplete observations lead to incorrect inferences. In a generator when an armature is revolved, current is generated. In a motor when current is supplied, the armature will turn. By coupling the two armatures we cannot cause perpetual motion.

7. Students will carry over their observations in the mixing of pigments into the topic of the mixing of lights. They will make wrong predictions of the results of mixing lights based upon their assumption that pigments and lights behave similarly.

8. A student's inference as to the weight of objects may be incorrect even though based upon correct observations of volume.

a. Show equal volumes of heavy and light woods.

b. Show unequal volumes of woods so selected that the smaller block is heavier than the larger.

B. Material effects are due to definite causes; by knowing causes, effects may be predicted.

1. Students' observations that parallel rays meet at the focus, and that rays through the optic axis are practically undeviated, may be used to predict all applications of a single lens. The characteristics of the image corresponding to an object placed at any position, may be predicted by drawing the appropriate lens diagram. This prediction can be checked experimentally by the students. The camera, enlarger, projector, simple microscope, etc., may then be designed.

2. The principle of work may be arrived at through the study of the lever and the inclined plane. This principle may be used to predict all the relationships (effort, resistance, effort-distance, resistance-distance) in the study of pulleys and the wheel-and-axle.

3. That the cause and effect relationship implicit in a theory gives us power to predict new phenomena can be clearly illustrated by

a. Using the kinetic theory of heat to predict cooling by evaporation, change of freezing and boiling point due to solutes, effect of pressure upon boiling points of liquids.

b. Using the electron theory to predict electrostatic induction, variation of resistance of conductors with temperature, length and cross-sectional area of conductors, operation of diode and triode tubes in radio.

c. Using the molecular theory of magnetism to predict the effect of heat and hammering on a magnet, effect of breaking a magnet into pieces.

4. From a study of the cause of resonance in sound, the possibility of resonance in other fields where periodic motion occurs can be predicted, e.g., mechanics, light and radio.

C. Generalizations to be sound must be based upon

a. Adequate and sufficiently large sampling of facts.

b. The use of facts within experimental limits.

1. After watching demonstrations of (a) manometer pressure gauge showing variation of pressure with depth and (b) balanced columns of liquids with different densities, the pupil may conclude that the weight of the liquid is the only factor determining the pressure. A demonstration of the hydrostatic paradox with a set of Pascal's vases will show the fallacies of his generalization. The weights of the liquids in the various vases are different, yet the pressures are the same.

2. The term solid, as used by students in speaking of solid wood or steel, is a generalization. To them it means a continuous substance with no spaces. This is also carried over into their concept of liquids. The following experiments are suggested to show the pupils that their concept of solidity is fallacious.

a. Mercury shower. Mercury in a wooden cup will come through the wood if the air pressure below the cup is reduced.

b. Experiments in diffusion.

1. An inflated rubber balloon set over a beaker of CS_2 will have a distinct odor when deflated later.
2. Illuminating gas will diffuse through an unglazed porcelain cup used as an air thermometer, and will push the column of water down.
3. A bottle filled with Lugol solution (I in KI) immersed in starch solution will show iodine diffusing through a membrane of gold-beater's skin stretched over the mouth of the bottle.

c. Experiments in osmosis.

d. Add 100 cc. of alcohol to 100 cc. of water and find a combined volume of less than 200 cc. The use of a control experiment of adding 100 cc. of water to 100 cc. of water and repeating with alcohol alone is important.

3. In the study of expansion, after a very limited series of demonstrations, the pupils are willing to generalize that all substances expand on being heated. That this is true within definite limits only, may be shown by demonstrations of the abnormal expansion of water.

4. Show the pupils the following experiments:

a. The same metal block at different temperatures melts different amounts of wax.

b. Equal weights of water at different temperatures melt different amounts of ice.

From these the pupil may draw the generalization that bodies with higher temperatures have more heat than those with lower temperatures. Show that the above generalization has limited validity by demonstrating the following:

a. Different quantities of water at the same temperature melt different quantities of ice.

b. Different metal blocks of equal weight and the same temperature melt different quantities of wax.

c. Equal weights of ice and of ice water at the same temperature cool equal weights of water at the same original temperature by different amounts.

d. Equal weights of steam and of boiling water at the same temperature will heat equal weights of water at the same original temperature by different amounts.

Thus the student will see the danger of generalizing on insufficient data.

5. During the study of conduction of electricity in solids, the student classes all substances as conductors or non-conductors. Show that non-conductors may become conductors under abnormal conditions.

a. Passage of electricity through air at low pressures (gas-tubes).

b. Passage of electricity through air at high voltages (spark, corona discharges).

c. Passage of electricity through glass near the melting point.

Various generalizations in the pupil's personal and social environment should be discussed after each of the above demon-

strations, e.g., the field of superstitions.

D. One must develop an open mind to newly-discovered facts and must be willing to revise one's opinions accordingly.

1. Discussion of the growth of the heliocentric theory versus the Ptolemaic theory of the solar system.

2. Discussion of Galileo's experiments with falling bodies.

3. Development of the kinetic theory of heat versus the caloric theory.

4. Wave versus the corpuscular theory of light from Newton's time to the present.

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SILK PILING UP IN JAPAN

Cut off from her best silk customer, the United States, Japan is reported to be piling up silk at the rate of 700 to 800 bales a day—as if caught in some ironic fairytale bewitchment in which riches and luxury mount in unwanted profusion.

Quantities of silk turned back from Japan's ports are being relayed to the interior, according to word received here by commerce officials. It is believed that the Japanese silk industry faces serious disorganization, for in addition to loss of the United States silk trade, Europe as a customer is virtually cut off by the Soviet-Nazi conflict.

American women need not picture Japanese women as the glamor girls of this winter, the only ones who are close to plenty of silk for making sheer hose. Actually, an ordinance reported in August sternly told women of the leisure class in Japan that they did not need stockings at all, and that the rationing system would give preference to working women in buying any kind of hosiery.

Besides reducing cocoon production, Japanese officials and scientists are casting about for various remedies for the silk dilemma. Rise of rayon and nylon had already spelled warnings to Japan that the silk industry, which is a mainstay of about 2,000,000 farm families, would have to be completely reorganized. Using some cocoons for making a wool substitute is one Japanese textile idea. Japan needs wool, and the farmers are accustomed to raising silkworms. Likelihood that Japanese people will be permitted and encouraged to use more silk is also foreseen. As war economy, Japanese have been restricted to wearing poorer grade silk and mixed textiles, so that high grade silk might be sold abroad.

STERILITY IN PLANTS

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"Sterility" is given many meanings, especially when applied to plants. The term is sometimes restricted to genetic sterility, excluding sterility due to environmental factors. Crane and Lawrence (5) carry this a step further when they regard incompatibility, not as a form of sterility, but as a separate phenomenon. At the other extreme, Jones (9) includes not only incompatibility but also sterility due to environmental causes. In this paper the term will be used in the latter sense. We may, then, consider a plant as sterile whenever it is unable to produce viable offspring. A plant is self-sterile if it cannot produce offspring by self fertilization, and cross-sterile with other plants if it cannot produce offspring by cross fertilization with them, whether they be in the same variety, species, genus, or even only within the same family. A plant is really cross-sterile with all other plants with which it cannot reproduce, though the term is usually restricted to plants which are more or less closely related. In all these cases we refer to sexual reproduction only, asexual reproduction or vegetative propagation not entering into the picture.

Many different schemes for classifying the various types of plant sterility have been evolved. The following classification has been compounded from the classifications of Jones (10), Crane and Lawrence (5), Dobzhansky (6), and Stout (16), but includes several original additions:

Types of Sterility in Plants

I. Ecological sterility. This type includes plants which have the hereditary potentialities for fertility, but are sterile due to certain environmental factors such as:
   1. Poor nutrition
   2. Disease
   3. Unfavorable water relations
   4. Photoperiods unfavorable for reproduction
   5. Temperature unfavorable for reproduction
   6. Seasonal isolation
   7. Spatial isolation
   8. Lack of pollinating agents (vectors)

II. Genetic sterility. This type includes plants which lack the

hereditary potentialities for fertility, and are sterile under most ordinary environmental conditions.

A. Genic sterility: due to morphological or physiological conditions under gene control.
   1. Morphological specialization (morphological incompatibility)
   2. Physiological incompatibility
   3. Abortion or suppression of reproductive structures
   4. Gene effects on gametogenesis

B. Chromosomal sterility: due to unusual chromosome structure or arrangement and resulting in the inability to form functional eggs, sperm or zygotes. May be referred to as impotence.
   1. Hybrid sterility
   2. Polyploidy and chromosomal changes

C. Cytoplasmic sterility: due to the influence of hereditary factors evidently transmitted through the cytoplasm.

Ecological Sterility

In plants nutritional sterility is largely tied up with the carbohydrate/nitrogen ratio. Kraus and Kraybill (11) found that when moisture and minerals, including nitrates, are abundant but carbohydrates very low, vegetation is weak and some plants are sterile. Under the same conditions, but with more carbohydrates available, the vegetation increases and may be luxuriant, but the plants are still sterile. A decrease in the nitrates in proportion to the carbohydrates reduces the luxuriance of the vegetation, but promotes fertility. A further reduction in the nitrates in ratio to the carbohydrates suppresses vegetative growth and again causes sterility. Nutritional sterility in animals is mostly related to lack of Vitamin E, but it is impossible to say whether such factors operate in plants.

Although disease is a more common cause of sterility in animals than in plants, nevertheless plants may become so badly diseased that they become stunted and unable to reproduce. Severe insect injury may produce the same results.

In the gametophytes of many bryophytes and pteridophytes a film of water must be present if the sperms are to swim from the antheridium to the archegonium and fertilize the eggs. By keeping fern gametophytes in an environment which was humid, but free from liquid water, Pace (13) was able to prevent fertilization for as long as three years, though abundant archegonia

and antheridia were present. The gametophytes grew into large, branching structures. Drouth may stunt a plant and prevent reproduction. On the other hand, water on the stigmas of clover and many other plants has been known to reduce the yield considerably by causing the explosion of the pollen, due to the high osmotic pressures resulting in them. Rainy weather during the time apple trees are blooming may reduce the apple crop markedly for this reason.

Garner and Allard and many others have demonstrated that the length of day is the principal factor determining the time of flower formation. Some plants bloom only under short days, some only under long days. By keeping a plant under a photoperiod unfavorable for blooming, flower production may be inhibited indefinitely. This factor is of considerable importance in determining plant distribution and the introduction of new cultivated species or varieties, for in the more northern lattitudes the day-length never gets short enough during the growing season to enable some short-day plants to reproduce, while in the tropics or sub-tropics the day-length never gets long enough to permit reproduction of some long-day plants. In other species of plants such as celery, cabbage (Thompson, 17) and stocks (Post, 14) temperature instead of the length of day control blooming.

Crosses between related varieties or species may be prevented solely by the fact that they do not bloom at the same time, this being known as seasonal isolation. Since the discovery of the photoperiodic (length-of-day) effect, it is now possible to bring such plants into bloom simultaneously and effect the otherwise impossible cross. If temperature regulates the time of blooming, it may be controlled similarly to permit crossing.

In nature crosses between two species or varieties may be prevented by separation by space or barriers. This may, of course, be overcome by human interference. Wiegand's account (19) of wild hybrids of *Crataegus* is of interest in this connection.

Many plants depend on specific insects for pollination. If these are absent reproduction fails. It is evident that this factor, and seasonal and spatial isolation, operate only in bringing about ecological cross-sterility. Unlike the first four ecological factors discussed, they do not produce self-sterility.

Genetic Sterility

We now come to a consideration of sterility in a stricter sense

of the term. Genetic sterility may be variously subdivided. Jones (9) divides it into incompatibility and impotence. Crane and Lawrence (5) use two classes: generational and morphological. They exclude incompatibility from their discussion of sterility and place it in a separate category. However, the writer prefers the division made by Dobzhansky (6) into genic and chromosomal sterility. As used here, genic sterility includes all hereditary potentialities which may prevent either self- or cross-fertilization or successful reproduction in any usual environment. Chromosomal sterility, sterility in the strictest sense of the word, includes those forms due to the inability of either meiosis or mitosis to proceed to a successful conclusion because of the structure or number of chromosomes involved. A third type of genetic sterility considered here is that due to factors transmitted through the cytoplasm.

Genic Sterility

Morphological Specialization: In this class we may include any usual structures which make fertilization impossible, either within a single individual or species, or between species. These may be considered as examples of morphological incompatability. Specialization of the reproductive apparatus reaches its climax in such plants as the orchids and milkweeds, with their complex flowers and pollinia. In them it would obviously be impossible for cross-pollination with other species to occur, at least in nature. Sterility may also result from much simpler morphological specializations. A style may be too long to permit the pollen tube to reach the ovule. To take an extreme case, what chance would pollen from a species having a short style and able to produce only a short pollen tube ever have of reaching the ovules of corn? In related plants where this factor operates fertility has been secured by cutting out a portion of the style and grafting the stigma back on. This phenomenon should not be confused with physiological incompatibility, in which the pollen tubes are kept from attaining their usual rate of growth or length.

The factors already mentioned operate primarily between plants of different species or genera. However, there are certain structural specializations which prevent self-pollination, though cross-pollination with other members of the species is possible One of these factors is heterostyly, the occurrence of different lengths of pistils in a species, with or without differences in the

lengths of the stamens. In *Primula* and *Linum* two kinds of flowers occur: thrum (short style, long stamens) and pin (long style, short stamens). These are examples of dimorphic heterostyly. In *Lythrum* and *Oxalis* we find trimorphic heterostyly, with three types of flowers: long styles and medium and short stamens; medium styles and long and short stamens; and short styles and medium and long stamens. Pollination is effective only between styles and stamens of the same length, thus resulting in self sterility under natural conditions. A similar result is achieved in dichogamy, the maturing of the pistils and stamens of a flower at different times. In some cases pollination from other flowers of the same plant is still possible, but even this is impossible in synchronous dichogamy. In this case dichogamy is simultaneous in all the flowers of a plant, all the pistils maturing at one time and all the anthers at another, in a daily or seasonal rhythm (Stout, 16) as in some of the avocados growing in Florida.

Still another factor prevents self-fertility: dioecism. This operates in all the higher animals, but in relatively few plants, and is the occurrence of the organs of one sex only in an individual. From a strictly morphological standpoint all higher plants *are* really unisexual, for the gametophytes which represent the true sexual generation never produce both gametes. However, although the sporophytes are actually sexually neutral and reproduce only by spores, from a practical standpoint we may perhaps regard them as either male or female or both, whatever the case may be.

These, as well as other genic sterility factors, have been classified as para-sterility by Brieger (3) in contrast with what he regards as true sterility (chromosomal sterility).

Physiological Incompatibility: We come now to one of the most interesting types of sterility in plants: incompatibility in the stricter or physiological sense. Unlike most of the other causes of sterility, incompatibility finds no counterpart in animals, with the possible exception of one Ascidian, *Ciona intestinelia* (East, 7). Most of the work on incompatibility has been done by East and Stout, although Correns (4) was one of the earliest investigators in the field.

In general, incompatibility is due to the failure of the pollen tube to reach the ovule, due to retarded or inhibited growth, although both the pollen and embryo sac are functional. Failure of the embryo to develop after its formation, as in early ripening

cherries (Tukey, 18), may also be regarded as a type of physiological incompatibility, as embryos have been removed before abortion and developed into seedlings on artificial media. Incompatibility is a type of selective fertilization as classified by Jones (10). Stout restricts the term *incompatibility* to intraspecies crosses and to self pollinations. He describes plants as being self- and cross-compatible or incompatible. Some species or cultures of plants are fully self-incompatible; some are composed of a mixture of self-incompatible and partially self-compatible plants; while others include in addition fully self-compatible individuals. In some species, factors for incompatibility seem to be entirely lacking. East reported in 1929 that, "The somewhat cursory examination of the literature that I have made has yielded a list of 176 self-sterile (incompatible) species, representing 55 familes and including both monocotyledons and dicotyledons." The number has been increased since that time. Incompatibility is the rule in plums and sweet cherries, and is found also in avocados, apples, and pears, though in the latter two plants much of the sterility is due to chromosomal factors. Other genera in which incompatibility occurs include *Cardemine*, *Linaria*, *Veronica*, *Verbascum*, *Nicotiana*, *Dianthus*, *Dahlia*, *Brassica*, *Resede*, *Chichorium*, *Lilium*, *Hemerocallis*, *Tradescantia*, and *Petunia* (Crane and Lawrence, 5).

The genetic basis of incompatibility is now well worked out. Stout (15) lists the following three types of incompatibility:

1. *Personate type.* This is the simplest and perhaps most common type of incompatibility. It is controlled by a single allelomorphic series of sterility factors (S1, S2, S3 . . .). In the simplest personate type all members of a species or race are normally self-incompatible.

2. *Capsella type.* In this type there are two series of S factors of different relative epistatic powers. All the pollen of an individual acts the same, in contrast with the preceding type. All individuals of a race or species are normally self-incompatible.

3. *Associate type.* Here there is a complex of reactions, both quantitative and qualitative, between two or more allelic series of two distinct types of hereditary factors, *S* and *F*. *S* operates to limit those fertilizations which result in genotypes homozygous for any one *S* factor, and to prevent self- and intra-fertilization of such genotypes when they do occur. *F* operates to favor fertilizations which result in genotypes homozygous for an *F* factor or which have certain genic balances for *S* and *F*.

Since it is impossible to discuss all three types in this paper, a description of the personate type will serve to indicate the nature of incompatibility reactions. Any one plant carries two of the allelomorphs. Pollen cannot function on the style of a plant carrying the same incompatibility factors as the pollen. The result is retarded or inhibited growth of the pollen tube, which consequently does not reach the ovule. Suppose we have a race of plants with four S allelomorphs: S1, S2, S3, and S4. The following chart indicates the possible genotypes and crosses. Plants having identical genotypes are completely sterile, indicated by "O." Thus, all plants are self-incompatible, and are cross-incompatible with other plants having the same genotype (Fig. 1). Individuals are completely fertile or cross-compatible with other individuals carrying a completely different set of genes (F). When one gene in the two plants is the same, only half of the pollen is able to function, and we get a condition of partial cross-incompatibility. Note, however, that all plants are self-incompatible.

East and Yarnell (8) claim that there may also be a fertility factor (Sf) in the series, and plants containing it will be self-compatible. Any cross involving the Sf gene will also be fertile.

S_1S_1	0									
S_1S_2	f	0								
S_1S_3	f	f	0							
S_1S_4	f	f	f	0						
S_2S_2	F	f	F	F	0					
S_2S_3	F	f	f	F	f	0				
S_2S_4	F	f	F	f	f	f	0			
S_3S_3	F	F	f	F	F	f	F	0		
S_3S_4	F	F	f	f	F	f	f	f	0	
S_4S_4	F	F	F	f	F	F	f	F	f	0
	S_1S_1	S_1S_2	S_1S_3	S_1S_4	S_2S_2	S_2S_3	S_2S_4	S_3S_3	S_3S_4	S_4S_4

FIG. 1. Possible Genotypes and Crosses in a Case of Incompatibility Controlled by Four Allelomorphs. Crosses marked "0" are sterile; those marked "F" are fertile; those marked "f" are only partly fertile because of the inhibition of half of the pollen.

If we self a plant of the constitution SfSx (x represents any other allelomorph) we should expect equal number of the following: SfSf, SxSx, and twice as many SfSx, the 1:2:1 ratio. However, SxSx fails to appear due to pollen tube inhibition, with the result that we get a ratio of 2 SfSx to 1 SfSf. All the offspring carry an Sf gene. Self-compatibility is possible in the personate type only in plants carrying an Sf gene, and they are really only three-fourths fertile.

Stout (15) lists the following interesting deviations of incompatibility from the normal:

1. *Partial variability.* Some flowers or ovules on a plant yield seeds while others do not.

2. *Haphazard pseudo-fertility.* Cases of limited fertility not related to the age of the flowers or the plant or special conditions.

3. *Cyclic self-incompatibility.* This is influenced by physiology due to the cycle of flowering, the age of the plant or the flower. In *Brassica pekinensia* and *B. chinensia* (Stout, 15) one group was completely incompatible at the beginning of the season and again at the end, compatible during mid-season, and grading through various degrees of partial compatibility between both intervals.

4. *Conditional self-compatibility.* Certain cacao trees are compatible at some times, not at others.

5. *End-season fertility.* Plants may be fertile at the end of the season, not at other times.

6. *Juvenile cross-incompatibility.* Some plants are incompatible when first coming into bloom, compatible later.

7. *Bud pollination.* Some plants are compatible if hand pollinated while still in the bud, but are incompatible later.

8. *Experimental manipulation.* Removal of the stigmatic secretion will make some self-incompatible plants compatible.

9. *Pseudo-fertility.* These plants have sterility factors, but the stigmatic secretions are modified by internal conditions so that fertility results.

These various deviations from normal are not so puzzling and inexplicable as they may seem when we remember that after all incompatibility is due to the inhibition or retardation of pollen tube growth, and that perhaps the balance of factors is often quite delicate, so that under special conditions the pollen tube is able to reach the ovules despite the physiological resistance to its growth.

Just what physiological set-up inhibits pollen tube growth is not well understood, but evidently the stigmatic secretion plays a part, and East (7) suggests that protein reactions may be involved.

Abortion or Suppression of Reproductive Structures: This occurs primarily in domesticated plants, which are propagated asexually and could probably not persist in nature. However, some wild species do not form functional flowers and reproduce vegetatively. The climax in this respect is probably reached by a duckweed, *Wolffiella,* which has not been observed to bloom at all. The other duckweeds rely almost entirely on vegetative reproduction. Among the many cultivated plants with some form of abortion or suppression it will suffice to mention the banana, with aborted ovules, the seedless orange, with suppressed ovules, and some of the hydrangeas which have neither stamens or pistils. In most double flowers stamens have changed into petals, and if all the stamens have been changed, sterility results. Among other examples given by Crane and Lawrence (5) are those of the Golden Esperen plum, whose anthers are contrabescent and do not contain good pollen; the J. H. Hale peach, which does not produce good pollen; and the abortive stamens of some strawberries.

Gene Effects on Gametogenesis: Meiosis and mitosis, like other processes and structures, are controlled by genes. Sterility may be caused by the presence of genes which cause meiosis to proceed abnormally, thus resulting in a failure in gametogenesis. For example, Dobzhansky (6) reports Beadle's studies on the asynaptic gene in corn. Plants homozygous for it abort most of their pollen and ovules. The beginning of meiosis is normal and the chromosomes pair, but no chiasmata are formed in most cases, the chromosomes fall apart, and univalents result. "The spindle elongates abnormally and aberrant chromosome complements are formed in the resulting daughter cells most of which degenerates." Genic sterility in corn is also caused by other pairs of genes affecting meiosis, for example the recessive "sticky" gene causes meiosis to be abnormal throughout.

In the strictest sense, as used for the most part by Dobzhansky, the term "genic sterility" should perhaps be restricted to this last type. However, the writer feels that it should apply to any sterility factor controlled by genes, whether operating at meiosis or elsewhere.

Chromosomal Sterility

Hybrid Sterility: Hybrid sterility is in most cases due to the considerable differences which exist in the chromosome sets received from the two parents. As a consequence, all or some of the chromosomes have no homologues with which to pair at synapsis, resulting in the failure of this process and the gamete formation which should follow. This may occur even if the chromosome sets from the two parents are of the same number, for they be of such different genic constitution as to make synapsis impossible. This type of sterility should not be confused with that described above in which meiotic failure is due to gene control and in which each chromosome has a true homologue.

Occasionally such sterile hybrids produce gametes containing the full un-reduced somatic chromosome complement. The union of two such gametes results in a fertile tetraploid which may result in the formation of a new species and even a new genus, as in the case of *Raphanobrassica,* a hybrid of the radish and cabbage. In these fertile tetraploids normal meiosis occurs.

Polyploidy and Other Chromosomal Changes: We have just mentioned that polyploidy may result in the production of fully fertile plants from essentially sterile ones. Strangely enough, polyploidy may also be a cause of sterility. Meiosis in polyploids is very complex and frequently breaks down. This is especially true of odd polyploids, i.e., triploids, pentaploids, etc. The triploid species in the genus *Prunus* are completely sterile and can be used only as ornamentals because they do not produce fruit. These include *P. nana, P. mume,* and the Japanese flowering cherries.

Apples and pears are either diploid or triploid. The percentage of bad pollen is much higher in all the triploids than the diploids, and is higher in the diploid pears than the diploid apples. According to Crane and Lawrence (5) Moffet (12) "showed that the degree of primary pairing and the secondary association of the chromosomes is not so great in pears as in apples, leading to greater irregularity at reduction and a greater degree of sterility."

In many plants such as tomatoes and raspberries the polyploid plants have been shown to be less fertile than the diploids, though not necessarily entirely sterile.

Various chromosomal changes such as deletions, duplications, translocations and inversions may be of such magnitude as to

make meiosis difficult, if not impossible, thus resulting in a reduction in fertility or in complete sterility.

Cytoplasmic Sterility

There is some evidence that at least in plants certain hereditary potentialities are transmitted through the cytoplasm rather than the chromosomes. Chittenden (3) describes an example of this which is responsible for a type of male sterility in flax.

The petals of the male sterile plants are much reduced and the anthers are more or less completely aborted, only occasionally forming functional pollen. This appears to be a simple Mendelian recessive to the usual condition, but occurs only when a plant of the procumbent strain is pollinated by a tall plant, not when a tall is pollinated by a procumbent.

If we let P and T represent homologous genes, blocks of genes, or even whole chromosomes of procumbent and tall respectively we can state that when T is homozygous in procumbent cytoplasm a male sterile plant is produced. TP or PP in procumbent cytoplasm gives a male fertile plant, as do all combinations in tall cytoplasm. It is evident that procumbent cytoplasm contains factors which, when interacting with the TT chromosome material, results in male sterility. The small amount of cytoplasm in the procumbent pollen explains the failure of male sterility to result from the pollination of a tall plant by a procumbent plant.

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RESEARCH IN PURE SCIENCE, A FACTOR IN NATIONAL DEFENSE

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With the signing of the Armistice in 1918, America "pigeonholed" her defense industries. She was firmly convinced that they would never again be needed. Now America is resurrecting these industries and is calling them to her aid. Industry is the key to this defense program, for the war of today is a war of machines. There is, however, a factor which is probably even more fundamental because upon it we have built the foundation on which modern industry stands. That factor is the record of the data that research has accumulated through the ages.

Research, even in its most abstract aspects, is a search for facts, and hence, by its very nature affords new information on the behavior of matter, which may eventually be of service to industry.[1] The difference between scientific and industrial research lies only in the point of view. Research for the purpose of observing the facts concerning the behavior of matter is theoretical or scientific research, whereas research for the purpose of finding a use for these observed facts is industrial research. Hence, we see that industrial research is nothing more than applied theoretical research. We cannot justly conclude that one is more important than the other. Rather we must say that there must be a proper balance of the two for greatest efficiency.

The laboratory reports of the theoretical scientists of past

[1] L. W. Bass, "Pure Research—As an Aid to Industrial Progress." *Oil, Paint, and Drug Reporter* 138 (July 22, 1940), p. 3.

centuries are the tools of the industrial research workers of today. In 1680, Christian Huygens described physical principles upon which an internal combustion engine could operate. These few facts form the foundation of the Diesel engine of today which cannot be surpassed for marine power and is being used today in most of our battleships. The mathematicians of past ages studied mathematical abstractions. It was their studies which led to the theory of statistics, an almost indispensable element in our modern economic system. Dusty volumes of *Chemisches Zentralblatt* are at the present time opening new fields for our modern chemists. Of these, that of synthetics is probably the most fascinating. It would, however, be almost impossible for chemists to synthesize vitamins or any other substance if they did not know the properties and reactions of intermediate substances recorded by their predecessors. In 1865, Mendel recorded facts and formulated the laws of heredity. Today, research men are using these facts to produce varieties of corn and wheat with more food value and less bulk. Thus, we see the importance of the scientific literature recorded by theoretical scientists to our present day research workers.

Research, the vital factor in defense, is not being underrated by our government. In June of 1940, President Roosevelt organized the National Defense Research Committee composed of eight of the country's leading scientists.[2] This executive agency was empowered to encourage and support research necessary to accelerate defense measures. Industrial and university laboratories all over the country were enrolled in the defense program and already the fruits are being gathered. Toluol, a material necessary for the production of T.N.T., was one of the supplies found to be insufficient in the United States. Immediately the scientists set out to find a new source of this material and already there is an increased supply of thirty million gallons per year.[3]

Research is something more than making a new product. It has wider consequence than the evolution of a new process. It is a development that adds a new section to the history of social as well as technologic progress. Many battles are won in the country's scientific and industrial laboratories and the fate of any nation may depend on the organization of its research ef-

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[2] S. Paul Johnston, "Research Girds for War." *Aviation*, 39 (Oct., 1940), pp. 40–41.

[3] "Toluol from Petroleum Defense Board Aim." *Oil, Paint, and Drug Reporter*, 47 (July, 1940), p. 18.

forts and the ability of research men to find the right answer at the right time.

The role of research will not pass with the present crisis, but rather its efforts will be concentrated on a different form of national defense. It will cooperate with other agencies in the rehabilitation of the nation's social and economic systems. Present defense orders are only a stimulant to industry and when the stimulant wears off we must be prepared. Some have said that depressions and unemployment are caused by "too much science and invention." Others can prove that invention makes more jobs than it destroys. Actually, there are two kinds of invention: labor-saving invention and labor-creating invention. It is labor-creating inventions that will help to prevent the recurrence of a complete dislocation of our social and economic systems such as followed 1917–18. We must make jobs by bringing forth new goods, new services, and new industries. At the present time there are about ten million jobs which would not exist had they not been created by research and invention.[4] Money invested in research today is the purchase of an "insurance-policy" for prosperity tomorrow.

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[4] Charles F. Kettering, "Ten Paths to Fame and Fortune," *American Magazine* (Dec. 1937).

The great desideratum for any science is its reduction to the smallest number of dominating principles.—J. CLARK MAXWELL.

THE USE OF PREYING MANTIDS IN THE LABORATORY OR CLASS ROOM

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For the past several years the writer has been making a study of preying mantids and the parasites that attack their egg cases. In so doing, it became necessary to collect many of the living mantids and keep them for a time in the laboratory. These insects proved so amenable to laboratory conditions, that the writer feels that the biology teacher who does not take advantage of this fact, will be missing a great opportunity to exhibit living animals in the laboratory or class room.

As most teachers know, the preying mantid is regarded with horror by many children and even by many adults. The many common names that have been applied to these insects including devil's horses, mule killers, soothsayers and others attest to these beliefs. Many people believe that the mantids are deadly poisonous, that they possess supernatural powers, and that they will spit in one's eyes. Needless to say, there is no scientific support for any of these beliefs. In fact, it is practically impossible for a mantid to injure one. It is of course true that when a person catches one of the insects, it will attempt to escape, and in so doing is likely to scratch the hand, or it may even attempt to bite. However, both these defensive measures are negligible. The writer has handled perhaps hundreds of these insects, and has never as yet had the skin broken on his hand. If one picks a mantid carefully, it will frequently not even attempt to escape.

Both the terms praying and preying are applied to mantids. The former is used because of the insect's habit of holding the front legs folded when at rest, which according to popular interpretation resembles an attitude of prayer. The term preying is used because the insects are predacious, and capture prey for food. The writer prefers the latter term because it is most descriptive, and to judge by the mantid's actions, there is perhaps a little doubt as to the insect's pious intentions.

Preying mantids are relatively common in most parts of the eastern United States, and beginning in the summer and fall, they can usually be collected relatively easily. This may be done by sweeping with an insect net fields in which the grass is rather long, or by carefully examining flowering plants and thus collecting them individually. During the fall, some species apparently

have the tendency to leave their feeding grounds and seek out small trees, weeds, or fence posts upon which to deposit their egg cases. Thus any region containing scattered mesquite, hack-berry or other small shrubs are likely to yield several mantids. They are also frequently found about dwellings on flowers or bushes.

In the eastern United States, the most common native species is the Carolina mantid (*Stagomantis carolina* (Joh.)), and most of the writer's work has been with this species. In certain parts of the north-eastern United States two or three Asiatic and European species have now become well established. The writer has not had any experience with these species, but it seems probable that these species would also be excellent laboratory subjects. It has been found that the females of the Carolina mantid are much more satisfactory as demonstrations than are the males. The females are apparently quite content provided the correct type of cage is used, and if they are kept well fed. The males however, have a tendency to crawl about the cage trying to get out, and do not eat well. Females of this species can be easily distinguished from the males. The tips of the wings do not reach to the end of the abdomen, and the posterior end of the body is much broader. The males are relatively slender, and the tips of the wings extend completely over the end of the abdomen. Since the males fly much better than do the females, they are often attracted to lights during the fall, but the females are very rarely found near lights.

Once the mantids are captured, the problem of fixing a suitable container for them is relatively simple. The writer uses bell jars about 12 inches high by 8 inches in diameter. This is ideal since the mantid can be easily seen from all sides. The bell jars are placed on a table on a piece of toweling paper. Inside the jar is put a long twig $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter, one end of which is allowed to rest on the table, while the other leans against the side of the bell jar. This twig gives the insect a place upon which to rest and a place upon which to deposit the egg cases. Mantids are apparently more content hanging head down from a twig than they are resting on a flat surface. Leaves should be removed from the twig, but if it is somewhat branched, this is better than a single unbranched limb. A hole in the top of the bell jar is used to add food, The insects should be fed a minimum of once a day, and if possible two or three times. They should be fed only living insects, since they will not eat dead animals. The

living insect should simply be put in the cage with the mantid—the mantid will prepare its own meal! Sometimes mantids can be induced to take dead insects if they are dangled in front of them on a string. Hard bodied insects such as beetles, and large insects should be avoided, unless one wishes to test the mantids reaction to such insects. Most soft bodied insects of moderate size such as roaches, young grasshoppers, flies, and butter-flies are eaten with relish. Since feeding the mantids always arouses interest, the insect should not be fed for some time before the demonstration so that it will react favorably. Certain individuals however, possess an amazing capacity, and will often eat many insects one after the other.

If bell jars are not available, almost any type of box with screen wire or glass on one or more sides should be satisfactory. Each insect should be kept in a separate container, since otherwise they will fight among themselves.

The writer has not found it necessary to be especially careful as far as heat and humidity is concerned, since the usual fall and winter laboratory temperature of about 75° to 80°F. seems to be acceptable to the mantids. At night however, it is best to turn off the heat and raise the windows slightly to be certain that the laboratory does not become too warm.

Female mantids with a minimum of care may live for several months in the laboratory, and the chances are that after a short time they will deposit egg cases. This is very interesting procedure which requires an hour or so for completion. In most instances, cases are deposited in the afternoon or at night. If the animal is kept well fed, she may deposit several cases over a period of a few weeks.

Mantid egg cases themselves when collected in the field are very interesting subjects of study. The hatching of the young mantids may be observed, and if several cases are collected, the chances are that some egg parasites will emerge in the laboratory. If the mantids are at all common, egg cases are easily collected. In Nature, egg deposition starts about Septmber 1 in the southern United States, but cases are easier to find after some of the leaves have fallen from the trees. The cases are in most instances deposited on the under surface of a twig, and they can be most readily located in regions where there are scattered small trees or shrubs. Mesquite, hackberry, fence posts, and even old buildings are favorite deposition places. A fresh case can be distinguished from an old case by its newer

appearance. By cutting into a few cases, one soon learns to distinguish them.

If it is so desired, young mantids can be reared in the laboratory by feeding them very small insects such as fruit flies.

There are several species of parasites that attack the egg cases, but there is only one species that the writer has found to be at all satisfactory for laboratory study. This species is a small wasp (*Podagrion mantis* Ashmead) and may be distinguished from the other species by the fact that the female possesses a long tail-like ovipositor on the end of the abdomen. Fortunately this species is the most common parasite in most parts of the country, so that if an egg case is parasitized, the chances are that it will be this species. The males of this species do not have the ovipositor, and they usually emerge from the egg case before the females. This particular species of parasite emerges from the egg case by gnawing holes in the sides of the case, or the bottom if the case has been removed from the substratum upon which it was originally deposited. Most other parasites emerge from the top of the egg case.

If the collected egg cases are parasitized, the parasites usually emerge after they have been in the laboratory for less than a month, and frequently within a few days. Once the parasites have emerged, they will within a day or so deposit eggs back into the case from which they have emerged, or will attack other egg cases. The process of egg deposition of the parasite is again a process that should be of interest to the student. The female insect rises on the tips of its tarsi, curls the tail-like ovipositor under the abdomen, and laboriously bores into the egg case. The complete procedure may require an hour or more for completion. They can be readily kept in the laboratory by placing them under a water glass on a piece of toweling paper. They will live longer if a piece of moistened dried fruit such as a raisin is kept in the container. For a more detailed discussion of the different species of parasites, the reader is referred to the first article listed in the bibliography.

In conclusion the writer would like to again emphasize that the teacher who does not take advantage of the opportunity to make use of preying mantids in the laboratory, may have missed the chance to stimulate the students' interest in the general subject of biology. As all teachers know, most students are intensely interested in living material, and quite frequently a simple exhibit of this type is all that is needed to stimulate the

student to undertake more important projects. The teacher who uses these insects in the laboratory will, in the writer's opinion, accomplish several things. He will be able to stimulate interest in the subject of biology in general; he will teach the student something of the biology of an intensely interesting insect; and he will help to prove untrue the many superstitions that are prevalent regarding one of the most unusual insects in our fauna.

Readers who are interested in more technical details of the parasities of the egg cases, or who desire additional information regarding the biology and rearing technique of the mantids themselves are referred to the articles listed in the selected bibliography.

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ON A PROBLEM OF STEINHAUS

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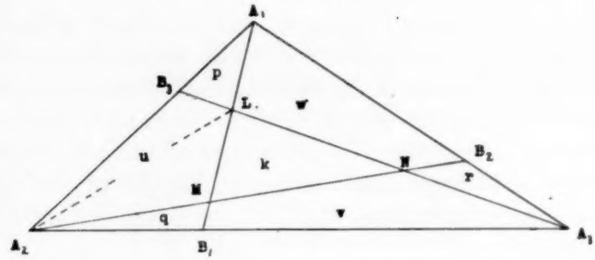
In his book, *Mathematical Snapshots*, Steinhaus[1] points out that if B_i is a point one-third of the way from A_j to A_k (where i, k, j is a cyclic permutation of 1, 2, 3) in the triangle $A_1A_2A_3$, then the small central triangle formed by the lines A_iB_i has an area one-seventh the area of the triangle $A_1A_2A_3$. There are several other interesting area relationships involving the corner triangles and the quadrilaterals formed by such a subdivision of the triangle $A_1A_2A_3$. Some of these are expressed in the following

Theorem. *If A_jB_i is equal to $1/n$ th $(n>0)$ A_jA_k, the area of the triangle formed by the lines A_iB_i is $(n-2)^2/(n^2-n+1)$ times the area of $A_1A_2A_3$; the areas of the corner triangles are each equal*

[1] H. Steinhaus, *Mathematical Snapshots*, Stechert and Co., p. 7.

to $1/n(n^2-n+1)$ *times the area of* $A_1A_2A_3$; *the areas of the quadrilaterals are each equal to* $(n^2-n-1)/n(n^2-n+1)$ *times the area of* $A_1A_2A_3$.



Proof: Denote the areas (see the figure) A_1B_3L A_2B_1M, A_3B_2N, B_3LMA_2, B_1MNA_3, B_2NLA_1, LMN, $A_1A_2A_3$, respectively by p q, r, u, v, w, k, and K. Then since $A_jB_i=A_jA_k/n$, and since the areas of triangles with equal altitudes have the same ratio as their bases it is evident that

(1) $$p+q+u=K/n,$$
(2) $$q+r+v=K/n,$$
(3) $$r+p+w=K/n,$$
(4) $$u+v+q+k=(n-1)K/n,$$
(5) $$v+w+r+k=(n-1)K/n, \quad \text{and}$$
(6) $$w+u+p+k=(n-1)K/n.$$

Also, since the area of the triangle $A_2B_1L=(k+v)/(n-1)$ and that of triangle $A_1A_2L=np$, it follows that $np+(k+v)/(n-1)=K/n$. Hence, rearranging, one has

(7) $$n(n-1)p+k+v=(n-1)K/n.$$

Similarly,

(8) $$n(n-1)q+k+w=(n-1)K/n,$$
(9) $$n(n-1)r+k+u=(n-1)K/n,$$

and of course,

(10) $$p+q+r+u+v+w+k=K.$$

From (1), (2), (3), and (10) one easily finds

(11) $$k=(p+q+r)+(n-3)K/n,$$

while from (4), (5), (6), and (10) it is clear that

(12) $$u+v+w+2k=(2n-3)K/n,$$

and, adding the equals of (7), (8), and (9), one has

(13) $$n(n-1)(p+q+r)+u+v+w+3k=3(n-1)K/n.$$

Now (11), (12), and (13) give three relationships from which p, q, r, u, v, and w are easily eliminated. Indeed, this elimination readily leads to the first result: namely,

$$k=(n-2)^2K/(n^2-n+1). \tag{14}$$

Again equating values of v from (2) and (7) and using (11) and (14) it is a matter of easy algebra to derive that

$$p=K/n(n^2-n+1).$$

Similarly, using (3), (8) and (1), (9), respectively, one can obtain exactly the same value for q and r, which establishes the second part of the theorem.

Finally with the values of p, q, and r already determined, finding u, v, and w is merely a matter of substitution in (1), (2), and (3). In fact, $u=v=w=(n^2-n-1)K/n(n^2-n+1)$ and the last part of the theorem is proved.

Since interesting special cases arise when particular values are assigned to n we note two corollaries.

COROLLARY 1. *For $n=(3\pm\sqrt{5})/2$ the central triangle has the same area as each of the corner triangles.*

COROLLARY 2. *For* $n=\frac{1}{3}\left[5+2\sqrt{10}\cos\left\{\frac{1}{3}\cos^{-1}\left(\frac{-\sqrt{10}}{100}\right)\right\}\right]$, $\frac{1}{3}\left[5+2\sqrt{10}\cos\left\{\frac{4\pi}{3}+\frac{1}{3}\cos^{-1}\left(\frac{-\sqrt{10}}{100}\right)\right\}\right]$, *the central triangle has the same area as each of the quadrilaterals.*

For the proof of the first of these one has but to observe that setting $k=p$ leads to $n=1$, $(3\pm\sqrt{5})/2$, and the first root is the only trivial root. Setting $k=u$ gives a proof of the second corollary. It is noteworthy that for no real value of n is $k=p=u$. If $u=2$, $p=u$ but in this case the quadrilaterals degenerate into triangles and the central triangle vanishes. Ceva's Theorem

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BODY "GETS USED" TO OXYGEN LACK AT HIGH ALTITUDES

When man flies or climbs to high altitudes his body "gets used" to the lack of oxygen in the upper atmosphere by a complex mechanism which keeps the blood from becoming too alkaline. The mechanism was explained by Major David B. Dill, U. S. Army Air Corps, at the meeting of the American Association for the Advancement of Science at Chicago.

Lack of oxygen in the arterial blood stimulates the carotid body, a nerve center near the carotid artery in the neck. This speeds up breathing, which raises the oxygen content of the blood. The resulting rise in alkalinity would ordinarily depress the brain's breathing center. But a buffering action by body proteins absorbs the alkalinity and keeps the blood chemical balance normal.

A CALENDAR OF THE BIRTHDAYS OF SCIENTISTS FOR NOVEMBER[1]

JAMES D. TELLER
College of Education, Ohio State University

Day	*Year*	*Name*	*Birthplace*	*Specialty*
1	1868	Robert Kennedy Duncan	Brantford, Ontario, Canada	Chemist
2	1849	Lájos de Lócz Lóczy	Pressburg, Bratislava, Hungary	Geologist
5	1855	Leon Philippe Teisserenc de Bort	Paris, France	Meteorologist
6	1830	John Whitaker Hulke[4]	Deal, Kent, England	Ophthalmologist
6	1848	Richard Jeffries	Coate near Swindon, England	Naturalist
7	1867	*Marie Sklodowska Curie	Warsaw, Poland	Physicist
7	1840	*Alexander Kovalevsky	Dünaberg, Russia	Embryologist
8	1860	Francis John Haverfield	Shipston-on-Stow	Archaeologist
8	1864	Benjamin Lincoln Robinson	Bloomington, Illinois	Botanist
8	1846	William Robertson Smith	Kieg, Aberdeenshire, Scotland	Archaeologist
10	1851	Waldemar Christofer Brögger	Oslo, Norway	Geologist
10	1861	William Shirley Bayley	Baltimore, Maryland	Geologist
11	1884	Friedrich Bergius	near Breslau, Germany	Chemist
12	1746	*Jacques Alexandre César Charles	Beaugency, Loiret, France	Physicist
12	1842	*John William Strutt Rayleigh	Essex, England	Physicist
13	1831	*James Clerk Maxwell	Edinburgh, Scotland	Physicist
14	1863	*Leo Hendrik Baekeland[3]	Ghent, Belgium	Chemist
14	1891	*Frederick Grant Banting[3]	Alliston, Ontario, Canada	Medical Research
14	1819	Frederick Crace Calvert	London, England	Chemist
14	1707	Auguste Laurent	La Folie, Haute Marne, France	Chemist
15	1738	*Sir Frederick William Herschel	Hanover, England	Astronomer
17	1850	Sir George Thomas Beilby	Edinburgh, Scotland	Chemist
17	1823	Sir John Evans	Bucks, England	Archaeologist
17	1645	Nicolas Lemery	Rouen, France	Chemist
17	1847	Archibald Liversidge	London, England	Chemist
17	1790	August Ferdinand Möbius	Schulpforta, Germany	Astronomer
18	1821	Franz Friedrich Ernst Brünnow	Berlin, Germany	Astronomer
18	1789	*Louis Jacques Mandé Daguerre[2]	Cormeilles, Seine-et-Oise, France	Inventor
18	1839	August Adolph Kundt	Schwerin, Mecklenburg, Germany	Physicist
19	1834	George Hermann Quincke	Frankfort on the Oder, Germany	Physicist
20	1851	John Merle Coulter	Ningpo, China	Botanist
20	1602	*Otto Von Guericke	Magdeburg, Saxony	Natural Philosopher
20	1762	Pierre André Latreille	Brives-la-Gaillarde, France	Naturalist
20	1862	Edward Alexander Westermarck	Helsingfors, Finland	Anthropologist
21	1785	*William Beaumont	Lebanon, Connecticut[2]	Physiologist
21	1818	Lewis Henry Morgan	near Aurora, New York	Ethnologist
21	1816	Augustus Volney Waller	Faversham, Kent, England	Physiologist
23	1715	Pierre Charles Lemannier	Paris, France	Astronomer
23	1864	Sir Peter Chalmers Mitchell	Dunfermline, Scotland	Zoologist
23	1887	*Henry Gwyn Jeffreys Moseley[4]	Weymouth, England	Physicist
23	1837	Johannes Diderik Van Der Waals	Leyden, Holland	Physicist
24	1863	Edwin Grant Conklin	Waldo, Ohio	Biologist
24	1876	*Hideyo Noguchi	Inawashiro, Yama, Fukushima, Japan	Bacteriologist
25	1814	*Julius Robert Mayer	Heilbronn, Germany	Physicist
26	1810	William George Armstrong	Newcastle-on-Tyne, England	Inventor
26	1832	Karl Rudolph König	Königsberg, Prussia	Physicist
26	1862	Sir Aurel Stein	Budapest, Hungary	Archaeologist
27	1701	*Anders Celsius	Uppsala, Sweden	Astronomer
27	1837	Edward Divers	London, England	Chemist
27	1848	*Henry Augustus Rowland	Honesdale, Pennsylvania	Physicist
28	1854	Gottlieb Haberlaudt	Ungarisch-Altenburg, Austria	Botanist
29	1803	*Christian Johann Doppler	Salzburg, Austria	Physicist
29	1849	*Sir John Ambrose Fleming	Lancaster, England	Physicist
29	1859	Sir Robert Abbott Hadfield	Sheffield, England	Metallurgist
30	1756	*Ernst Florens Friedrich Chladni	Wittenberg, Germany	Physicist
30	1869	*Gustaf Dalen	Stenstorp, Sweden	Inventor
30	1817	Theodor Mommsen	Garding, in Schleswig, Germany	Archaeologist
30	1827	*St. George Jackson Mivart	London, England	Biologist
30	1823	Nathaniel Pringsheim	Wziesko in Silesia, Germany	Botanist
30	1800	Franz Unger	Amthof in Steiermark, Austria	Botanist

[1] Unless otherwise indicated all data are taken from *The Encyclopaedia Britannica*, 14th edition. For the limitations and uses of such a calendar, the reader is referred to the article which accompanies the calendar for October in SCHOOL SCIENCE AND MATHEMATICS, Vol. XLI, pp. 611–619, Oct. 1941.
[2] Data taken from *The Encyclopedia Americana*, 1939 edition.
[3] Data taken from *American Men of Science*, 4th edition.
[4] Data taken from *The Dictionary of National Biography*, 1921 edition.
* The names starred have been used by the writer in various bulletin board projects during the past twelve years.

TEACHER-PUPIL APPRAISALS OF 150 SCIENCE AND MATHEMATICS FILMS

LYLE F. STEWART
Director of Visual Education, Oak Park and River Forest Township High School, Oak Park, Illinois

Complete records have been kept of the films used by classes in the Oak Park and River Forest Twp. High School during the past three years. The records include the dates when each film was used, exact film title, length of film, type of film (sound or silent), content, name and grade level of classes (subjects) using the film, teacher and pupil appraisals, and suggestions for future use. Teachers report that these accumulative records add materially to the effectiveness of visual aids for classroom work.

The information provided by the accumulative records, except for the film content, was obtained from film appraisal forms. These forms were planned to obtain a maximum of infor-

FILM APPRAISAL ______ ______ ______
mo. day yr.

Title ________________________________ (______) (______)
sound silent

Teacher ____________________ Subject ____________________

Grade level of classes *Fr* *So* *Jr* *Sr*

Other subjects where the film may prove effective. ____________________

GENERAL APPRAISAL:............ Excellent..... (______)
Good......... (______)
Fair.......... (______)
Poor......... (______)
Detrimental... (______)

---

1. *How would you prefer to use this film in the future?*
   a. As an introduction to the unit.... (______)
   b. During the unit of work.......... (______)
   c. As a review of the unit........... (______)

2. Does the subject content in this film warrant two showings? (______) yes (______) no

3. Are there serious mistakes in the film? (______) yes (______) no

4. Will you probably use this film the next time you teach the unit? (______) yes (______) no

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COMMENTS

FIG. 1. Film Appraisal Form.

mation, essential for effective class use, with a minimum of teacher time. Our present appraisal forms (Fig. 1) are the result of several revisions, based upon recommendations made by teachers during the past three years.

Large numbers of educational films are now available for a wide variety of topics. Some of these films have titles that are very similar but have contents that are very different; for example, the film *Life Under The South Seas* (one reel, sound) includes studies of anemone, sea urchin, starfish, and jelly fish while the film *Life In The South Seas* (one reel, sound) deals with the primitive life and customs of the South Sea Islanders. Other films with similar titles have contents on the same general material but emphasize different aspects of the subject. The film *Earthworm* (two reels, sound) includes the external features and the dissection of main organs and systems while the film *Earthworms* (one reel, sound) emphasizes the reproductive processes and work in enriching the soil. There are a few different films that have titles that are identical; for example, one film entitled *Behind the Cup* is a two-reel silent film (black and white) while a second film with the identical title is a four-reel sound film in technicolor.

You will note that one of the films on earthworms was a two-reel sound picture while the other was a one-reel sound picture. One of the two films with the same title (*Behind the Cup*) was a two-reel silent picture while the other was a four-reel sound picture in technicolor. These examples demonstrate the importance of recording the number of reels, type of film (sound or silent) and type of emulsion (black and white or color) in addition to the exact film title, on all film orders and appraisal forms.

The educational motion picture now represents one of several specialized tools that facilitates the attainment of teaching objectives. It follows that a teacher may, from time to time, vary the use of a given motion picture, and that different teachers may find different uses for the same picture. Therefore the comments requested for our film appraisals emphasize general information such as the time and place where films may be used to advantage rather than suggestions of specific teaching methods.

Film appraisals provide a basis for selecting and using motion pictures in different subjects. The reactions of teachers and pupils who have used a film as a part of their class work are made available to teachers who have not seen the film. This informa-

tion prevents the subsequent use of a film in courses where it has been found unsatisfactory. It also provides constructive suggestions concerning the future use of the film for subjects and topics for which the picture seems especially adapted. An outstanding example of this was provided by the film *Anti-Freeze* which was ordered by the chemistry department. The chemistry teachers rated the film as poor for chemistry but recommended it for general science classes. The science teachers rated the film as fair (to good) for general science and recommended it for auto shop. The industrial arts department rated the film as very good for classes in auto mechanics and in turn recommended it for general science. As the result of these ratings and recommendations the film *Anti-Freeze* is used in all of our auto mechanics classes and in the general science classes that are made up largely of boys.

The appraisals often show that a given film may be equally worthwhile for subjects in different departments. A good silent or sound moving picture constitutes a carefully selected experience. Just as experience includes a cross-section of several "compartments" of subject matter, so the learning from moving pictures may break down subject-matter barriers. Suggestions and ratings recorded from film appraisals have resulted in our using the film *The Plow that Broke the Plains* for classes in American history, economics, social problems, biology, botany, geography and general science. Likewise, we are now planning to use the film *Steel, Man's Servant* for classes in chemistry, general science, industrial arts, economics and English. This unifying of subject matter represents one of the very important functions of motion pictures.

AVERAGES OF THE APPRAISALS OF 150 FILMS BY TEACHERS AND PUPILS OF THE OAK PARK AND RIVER FOREST TWP. HIGH SCHOOL*

FILM TITLES	Reels	Sound or Silent†	SUBJECTS									
			Biology	Botany	Chemistry	Gen. Sci.	Geography	Physics	Zoology	Math.	Home Ec.	Clubs
1—A New World Through Chemistry	2	So	—	—	F	x	—	—	—	—	—	—
2—Air Currents and Theory of Streamlining	1	So	—	—	—	G	—	x	—	—	—	—
3—Air Liner	2	So	—	—	—	x	—	—	—	—	—	E
4—Air Waves	1	So	—	—	—	G	—	—	—	—	—	E
5—The Alimentary Tract	1	So	x	—	—	—	—	—	E	—	—	—
6—Amoeba and Vorticella	1	So	E	—	—	—	—	—	E	—	—	—

FILM TITLES	Reels	Sound or Silent	SUBJECTS									
			Biology	Botany	Chemistry	Gen. Sci.	Geography	Physics	Zoology	Math.	Home Ec.	Clubs
7—Anti-Freeze (Ind. Arts—G)	2	So	—	—	P	F	—	—	—	—	—	G
8—The Ant Lion	1	So	E	—	—	—	—	—	E	—	—	—
9—Anthracite Coal	1	S	—	—	—	G	G	—	—	—	—	x
10—Autogiro	1	So	—	—	—	x	—	—	—	—	—	G
11—Bacteria	1	S	G	G	—	x	—	—	—	—	—	—
12—Battle of the Centuries	1	So	E	—	—	—	—	—	E	—	—	—
13—Beach and Sea Animals	1	So	G	—	—	—	—	—	F	—	—	—
14—Bees, Wasps, Ants, and Allies	1	S	E	—	—	—	—	—	G	—	—	—
15—Beetles	1	So	G	—	—	x	—	—	G	—	—	—
16—Behavior of Light	1	S	—	—	—	G	—	x	—	—	—	—
17—Behind the Cup (technicolor)	4	So	E	E	—	x	—	—	—	—	E	E
18—Birds of Prey	1	S	G	—	—	—	—	—	G	—	—	—
19—Birth of the Earth	3	So	E	—	—	x	x	—	x	—	—	x
20—Body Defenses Against Disease	1	So	E	—	—	E	—	—	E	—	—	—
21—Butterflies and Moths	1	S	G	—	—	—	—	—	G	—	—	—
22—Cancer, Its Cure and Prevention	1	So	G	—	—	—	—	—	G	—	—	—
23—Cane Sugar	2	S	—	—	—	—	—	—	—	—	—	P
24—Carbon Oxygen Cycle	1	S	E	E	—	G	—	—	x	—	—	—
25—Catalysis	1	So	—	—	G	—	—	—	—	—	—	—
26—Chemistry of Combustion	1	So	—	—	P	—	—	—	—	—	—	—
27—Chemical Effects of Electricity	1	S	—	—	—	F	—	—	—	—	—	—
28—Chemistry in a Changing World	1	So	—	—	E	x	—	—	—	—	—	—
29—Citrus on Parade (technicolor)	3	So	x	E	—	x	—	—	—	—	E	—
30—Clouds	1	S	—	—	—	F	—	—	—	—	—	—
31—Coffee	1	S	—	—	—	x	—	—	—	—	F	—
32—Colloids	1	So	—	—	E	—	—	x	—	—	—	—
33—Conquest of the Air	4	So	—	—	—	E	—	x	—	—	—	x
34—Corn	1	S	P	—	—	—	—	—	—	—	P	—
35—Cotton—From Seed to Cloth	2	S	x	G	—	—	—	—	—	—	G	—
36—Cycle of Erosion	1	S	—	—	—	G	G	—	—	—	—	—
37—Diesel, The Modern Power	2	So	—	—	—	G	—	x	—	—	—	x
38—Digestion of Foods	1	So	E	—	—	G	—	—	E	—	—	—
39—Diphtheria	1	S	x	—	—	E	—	—	x	—	—	—
40—The Dodder	1	So	x	E	—	x	—	—	—	—	—	—
41—The Earth In Motion	1	So	—	—	—	E	—	—	—	—	—	—
42—Earth's Rocky Crust	1	So	x	x	—	E	E	—	—	—	—	—
43—Earthworms	1	So	x	—	—	—	—	—	F	—	—	—
44—Einstein's Theory of Relativity	2	S	—	—	—	—	—	x	—	G	—	—
45—Electrons	1	So	—	—	G	—	—	x	—	—	—	—
46—Evolution	3	So	E	x	—	—	—	—	E	—	—	—
47—Evolution of the Oil Industry	3	S	—	—	—	G	x	—	—	—	—	x
48—Exploring the Universe	1	So	—	—	—	G	—	—	—	—	—	—
49—Exploring the Upper Air	1	S	—	—	—	P	—	—	—	—	—	—
50—Flax To Linen	1	S	—	—	—	—	x	—	—	—	G	—
51—Flowers at Work	1	So	G	G	—	x	—	—	—	—	—	—
52—Food Shot From Guns	1	S	x	x	—	x	—	—	—	—	G	—
53—The (Ford) Rouge Plant	4	So	—	—	—	E	—	x	—	—	—	E
54—Forest and Wealth (outdated)	1	So	—	P	—	—	—	—	—	—	—	—
55—Forest Serves Man	1	So	—	P	—	—	—	—	—	—	—	—
56—Forest Treasures (Ind. Arts—E)	3	So	G	G	—	G	—	—	—	—	—	x
57—Formation of Soil	1	S	F	F	—	F	x	—	—	—	—	—
58—Four-stroke-cycle Gas Engine	1	S	—	—	—	G	—	F	—	—	—	—
59—The Frog	1	So	x	—	—	—	—	—	E	—	—	—
60—Fundamentals of Acoustics	1	So	—	—	—	x	—	G	—	—	—	—

FILM TITLES	Reels	Sound or Silent	SUBJECTS									
			Biology	Botany	Chemistry	Gen. Sci.	Geography	Physics	Zoology	Math.	Home Ec.	Clubs
61—From Clay to Bronze (Ind. Arts—E)	3	S	—	—	—	x	—	—	—	—	—	—
62—Fungus Plants	1	So	x	G	—	x	—	—	—	—	—	—
63—Game Birds	1	S	x	—	—	x	—	—	G	—	—	—
64—Gathering Moss	1	So	x	E	—	—	—	—	—	—	—	—
65—Geometry	2	S	—	—	—	—	—	—	—	F	—	—
66—Glaciers	1	So	—	—	—	G	G	—	—	—	—	—
67—Grass	4	S	x	G	—	—	—	—	—	—	—	—
68—Green Plant	1	S	E	x	—	G	—	—	—	—	—	—
69—Heart and Circulation of the Blood	1	So	E	—	—	E	—	—	E	—	—	—
70—History of Aviation	3	So	—	—	—	F	—	—	—	—	—	—
71—Hot Air Heating	1	S	—	—	—	G	—	—	—	—	—	—
72—The House Fly	1	S	x	—	—	x	—	—	G	—	—	—
73—Island of Sugar	1	S	—	P	—	—	—	—	—	—	P	—
74—The Killers	1	So	E	—	—	—	—	—	E	—	—	—
75—Killing the Killer	1	So	E	—	—	—	—	—	E	—	—	x
76—Lead Mining in S. E. Mo.	3	So	—	—	—	E	x	—	—	—	—	—
77—Leaping Through Life	1	So	x	—	—	x	—	—	G	—	—	—
78—Leaves	1	So	x	E	—	x	—	—	—	—	—	—
79—Life and Habits of the Silkworm	1	S	x	—	—	—	—	—	G	—	—	—
80—Life Under the South Seas	1	So	E	—	—	—	—	—	G	—	—	—
81—Light Waves and Their Uses	1	So	—	—	—	G	—	x	—	—	—	—
82—The Living Cell	1	S	x	—	—	—	—	—	G	—	—	—
83—Living Jewels	1	So	x	—	—	—	—	—	G	—	—	x
84—Loaf of Bread	1	S	—	—	—	G	—	—	—	—	G	—
85—Loaf with Maca	1	So	—	—	—	G	—	—	—	—	G	—
86—Louis Pasteur, Anthrax	2	So	E	E	—	x	—	—	x	—	—	—
87—Louis Pasteur, Hydrophobia	2	So	E	E	—	x	—	—	x	—	—	—
88—Man Eating Sharks	1	So	G	—	—	—	—	—	x	—	—	G
89—Marine Life	1	So	x	—	—	—	—	—	G	—	—	—
90—Marshland Mysteries (technicolor)	1	S	G	—	—	x	—	—	x	—	—	—
91—Meat and Romance	4	So	—	—	—	E	—	—	—	—	E	E
92—Meat Packing	1	S	—	—	—	x	—	—	—	—	F	—
93—Mechanisms of Breathing	1	So	E	—	—	E	—	—	E	—	—	—
94—Microscopic Animal Life	1	S	E	—	—	—	—	—	G	—	—	—
95—Modes and Motors	1	So	—	—	—	G	—	—	—	—	—	—
96—Mold and Yeast	½	S	x	G	—	—	—	—	—	—	—	—
97—Molecular Theory of Matter	1	So	—	—	E	F	—	G	—	—	—	—
98—The Moon	1	So	—	—	—	F	—	—	—	—	—	—
99—Mosquitoes and Malaria	1	So	G	—	—	—	—	—	E	—	—	—
100—Mountain Building	1	So	—	—	—	E	E	—	—	—	—	—
101—Neptune's Mysteries	1	So	x	—	—	—	—	—	G	—	—	—
102—Nervous System	1	So	E	—	—	x	—	—	E	—	—	—
103—New Romance of Glass	2	So	—	—	—	E	—	—	—	—	E	x
104—Nitrogen Cycle	1	S	x	E	—	x	—	—	—	—	—	—
105—On to Jupiter	2	So	G	—	—	E	E	—	—	—	—	x
106—Operation of a Forest Nursery	1	So	x	E	—	x	—	—	—	—	—	—
107—Oxidation and Reduction	1	So	—	—	G	x	—	—	—	—	—	—
108—Oysters	1	S	x	—	—	—	—	—	F	—	—	—
109—Pacific Coast Salmon	1	S	x	—	—	—	—	—	G	—	—	—
110—Pirates of the Deep	1	So	E	—	—	—	—	—	G	—	—	x
111—Plant Growth	1	So	x	E	—	x	—	—	—	—	—	—

FILM TITLES	Reels	Sound or Silent	SUBJECTS									
			Biology	Botany	Chemistry	Gen. Sci.	Geography	Physics	Zoology	Math.	Home Ec.	Clubs
112—Plant Power	2	So	G	G	—	—	—	—	—	—	—	—
113—Plant Traps	1	So	x	E	—	—	—	—	—	—	—	—
114—The Plow that Broke the Plains	3	So	G	E	—	G	E	—	—	—	—	—
115—Precious Land	1	So	G	G	—	—	G	—	—	—	—	—
116—Producing Crude Oil	1	S	—	—	—	G	x	—	—	—	—	—
117—The Prowlers	1	So	—	—	—	—	—	—	—	—	—	F
118—Radio and Television	1	So	—	—	—	x	—	—	—	—	—	G
119—Rain for the Earth	2	So	x	E	—	—	x	—	—	—	—	—
120—Reactions in Plants and Animals	1	So	G	x	—	—	—	—	x	—	—	—
121—Rectilinear Coordinates	2	S	—	—	—	—	—	—	—	P	—	—
122—Refining Crude Oil	1	S	—	—	—	G	x	—	—	—	—	—
123—Refrigeration	1	S	—	—	—	G	—	x	—	—	—	—
124—Reptiles	1	S	x	—	—	x	—	—	G	—	—	—
125—The River	3	So	x	E	—	E	x	—	—	—	—	x
126—Roots of Plants	1	So	x	E	—	x	—	—	—	—	—	—
127—Safety On the Highway	1	So	—	—	—	G	—	—	—	—	—	x
128—Science Rules the Rouge (Auto Mech.—G)	2	So	—	—	—	x	—	—	—	—	—	G
129—The Sea Killers	2	So	x	—	—	—	—	—	E	—	—	x
130—Seed Dispersal	1	So	E	E	—	E	—	—	—	—	—	—
131—Sensitivity of Plants	2	So	E	E	—	E	—	—	—	—	—	—
132—Solar Family	1	So	—	—	—	G	x	—	—	—	—	—
133—Some Friendly Birds	1	S	G	—	—	x	—	—	G	—	—	—
134—Sound Waves and Their Sources	1	So	—	—	—	G	—	G	—	—	—	—
135—Spiders	1	S	x	—	—	—	—	—	G	—	—	—
136—Spring's Signature	1	So	x	F	—	—	—	—	—	—	—	—
137—Steel, Man's Servant (technicolor)	4	So	—	—	E	E	—	x	—	—	—	E
138—Television	1	So	—	—	—	E	—	—	—	—	—	x
139—Through Galileo's Telescope	1	So	—	—	—	E	x	—	—	—	—	—
140—Tree and Plant Life	1	So	x	G	—	—	—	—	—	—	—	—
141—Tiger, Tiger	1	So	—	—	—	—	—	—	—	—	—	F
142—The U.S.S. Macon	2	S	—	—	—	x	—	—	—	—	—	F
143—Velocity of Chemical Reactions	1	So	—	—	G	—	—	—	—	—	—	—
144—Vitamin Secrets Revealed	1	S	—	—	—	F	—	—	F	—	—	—
145—War on Insects	1	So	G	—	—	x	—	—	G	—	—	—
146—Wearing Away of the Land	1	So	G	—	—	E	x	—	—	—	—	—
147—Weather Forecasting	1	S	—	—	—	x	F	—	—	—	—	—
148—Wheels Across Africa	3	So	x	x	—	—	x	—	x	—	—	E
149—Where Mileage Begins	2	So	—	—	—	E	—	—	—	—	—	E
150—Yesterday, Today and Tomorrow	3	So	G	G	—	x	—	—	—	—	—	E

* E—Excellent.
G—Good.
F—Fair.
P—Poor.
x—Subjects suggested by teachers and pupils where the film may prove effective.

† So—Sound motion picture.
S —Silent motion picture.

Many a man has thrown himself with zeal into the study of Maxwell's work, and, even when he has not stumbled upon unwonted mathematical difficulties, has nevertheless been compelled to abandon the hope of forming for himself an altogether consistent conception of Maxwell's ideas. I have fared no better myself.—HENRY HERTZ.

Central Association of Science and Mathematics Teachers

CONVENTION PROGRAM

Stevens Hotel, Chicago, November 21–22, 1941

FRIDAY THROUGH SATURDAY

The latest text books and apparatus will be displayed by the companies engaged in meeting the needs of science and mathematics teaching. The latest motion picture films will be shown.

FRIDAY MORNING

8:00 to 9:45 Registration and visitation of exhibits

9:45 to 12:00 General Program; Chairman, Harold H. Metcalf, Oak Park & River Forest Twp. High School

"Application of Mathematics to Science"
Arthur Compton, University of Chicago

"Trends in Science Teaching"
Ira Davis, University of Wisconsin

"Trends in Mathematics Teaching"
Mary A. Potter, Racine Public Schools

"How the Scientist Studies Vitamins"
C. A. Elvehjem, University of Wisconsin

FRIDAY NOON: 12:15 Geography Conservation Group; Chairman, Villa B. Smith, John Hay High School, Cleveland, Ohio

Luncheon meeting open to all members

"The Geographic Basis of Conservation"
G. Donald Hudson, Northwestern University

FRIDAY AFTERNOON

2:00 to 4:30 Section Meetings

Biology Section. Chairman, Jos. W. Rhodes
Beloit High School, Beloit, Wisconsin

"New Materials in Biology Teaching"
Kirk Stevenson, Schurz High School, Chicago

"Ecology of the Tropical Rain Forest of Panama"
Ralph Buchsbaum, University of Chicago

"Using Latex in the Making of Models for the Biology Laboratory"
I. P. Daniel, Lakeview High School, Chicago

"The Relation of Vitamins to Different Forms of Living Matter"
C. A. Elvehjem, University of Wisconsin

"The Greenhouse in Biology Instruction"
M. C. Lichtenwalter, Lane Tech. High School, Chicago

Chemistry Section. Chairman, Sherman R. Wilson
Northwestern High School, Detroit, Michigan

"The Progress of the National Science Committee"
Emil Massey, Detroit Public Schools

"Vitamins and Minerals in Relation to National Health"
H. B. Lewis, University of Michigan

"Round Table Discussion on Consumer Chemistry"
Allen R. Moore, Morton High School, Cicero, Illinois
Norvil Beeman, Oak Park & River Forest High School
W. W. Kronsagen, Glenbard High School, Glen Ellyn, Ill.

Elementary Science Section. Chairman, Mary Melrose
Supervisor of Science, Elementary Schools, Cleveland, Ohio

"A Demonstration Lesson"
Glenn O. Blough, University of Chicago Elementary School

"Teaching Conservation in the Fifth Grade"
Dwight K. Curtis, State University of Iowa Elementary School

"How Can the Science Curriculum School Help Teachers?"
Anna E. Burgess, Prin. Miles Standish School, Cleveland

General Science Section. Chairman, H. A. Oetting
East Alton, Wood River High School, Wood River, Illinois

"Visual Aid Program in Science at the East Alton-Wood River Community High School"
A. W. Hendersen, Community High School, Wood River, Ill.

"Are General Science Courses Meeting the Needs of the Student"
Willard M. Gersbacher, Southern Ill. Normal University

"Scientific Attitudes in Children in Time of Crises"
Eggert Meyer, Francis Parker High School, Chicago

"Techniques in the Demonstration of Liquid Air"
Alden Greene, Proviso High School, Maywood, Illinois

Geography Conservation Section. Chairman, Charlotte L. Grant
Arsenal Technical High School, Indianapolis, Indiana

"Wielding Public Opinion Through Conservation Education"
George Duthie, U. S. Conservation Dept., Washington, D. C.

Mathematics Section. Chairman, H. G. Ayre
State Teacher's College, Macomb, Illinois

"Making and Using Moving Pictures for the Teaching of Mathematics"
Henry W. Syer, Culver Military Academy

"Mathematics and Music"
Anatol Rapaport, University of Chicago

"Mathematics Illustrated by an Exhibit"
Chairman, W. A. Richards, Morton High School, Cicero, Ill.
Mildred Taylor, Bernice Engels, Ruth Mason Ballard,
H. C. Torreyson, G. L. Anderberg, W. A. Spencer

Physics Section. Chairman, Geo. E. O. Peterson
Schurz High School, Chicago, Illinois

"The Problem of Physics In The High Schools"
K. Lark Horovitz, Purdue University

"Making Physics Interesting to High School Students"
C. W. Jarvis, Ohio Wesleyan University

"Developments in Meteorology"
C. G. Rossby, University of Chicago

"Demonstration of New Apparatus"

4:30 to 6:00 Exhibits and Motion Pictures

FRIDAY EVENING

6:30 to 10:00 Reception and Annual Banquet; Toastmaster, Otis W. Caldwell, Boyce Thompson Institute, Yonkers, New York

"The Artificial Creation of Speech"
J. O. Perrine, American Telephone & Telegraph Co.
Dr. Perrine gave the stimulating demonstration, "Words, wires, and waves," at the 1938 banquet in the LaSalle Hotel.

SATURDAY MORNING

8:00 to 9:00 Annual Business Meeting; Chairman, Harold H. Metcalf
Oak Park-River Forest Twp. H.S., Oak Park, Ill.

9:00 to 10:10 General Meeting; Chairman, Franklin Frey
Waukegan Township High School, Waukegan, Ill.

"The Training of Science Teachers"
S. R. Powers, Columbia University

"Into Unseen Worlds—The Electron Microscope"
James Hillier, R.C.A. Manufacturing Co., Camden, N. J.

10:15 to 12:00 Section Meetings
Elementary School Section. Chairman, Paul E. Kambly
University of Iowa

"An Activity in Measurement"
Demonstration by a 5th grade class of Gage Park Elementary School, in charge of Bernadette V. Greig
Devised by J. T. Johnson, Chicago Teacher's College

"Round Table Discussion"
Chairman, H. F. Spitzer, State University School, Iowa City, Iowa

W. C. Croxton, Minnesota State Teachers' College, St. Cloud, Minnesota

Glenn O. Blough, University of Chicago
Anna E. Burgess, Miles Standish School, Cleveland, Ohio
Dwight K. Curtis, State University School, Iowa
J. T. Johnson, Chicago Teachers College

Junior High School Section. Chairman, Anna P. Keller
Ass't Supt. of Schools, Chicago, Illinois

"The Determination of Taxes for the Community"
Demonstration class under the direction of
Marie W. Sperks, Farnsworth School, Chicago, Ill.

"Making Records of Nature's Forms"
Anna P. Keller, Dist. Supt. Chicago

"Reading Nature's Records"
May Theilgaard Watts, Author and Science Lecturer, Naperville, Illinois

Senior High School Section. Chairman, George E. Hawkins
Lyons Township Junior College, Lagrange, Ill.

"A Mathematics Program with Emphasis on General Education"
Harold Fawcett, Ohio State University

"The Science Teacher of the Future"
Robert J. Havighurst, University of Chicago

Junior College Section. Chairman, W. C. Krathwohl
Illinois Institute of Technology

"Science in Education; Responsibilities of Scientists and Teachers of Science"
Sister Mary Ellen O'Hanlon, Rosary College, River Forest, Ill.

"Abilities and Inabilities of University Students in Freshman Mathematics"
M. W. Keller, Purdue University

Come to Chicago for this fine meeting. If not a member of the Association and you wish a yearbook, please write for one. The yearbook gives the program in detail. Harold H. Metcalf.

MANY NEW TECHNICIANS WILL BE NEEDED IN GOVERNMENT WORK

All colleges and universities in the United States have been urged to increase their output of technically trained young men to meet the estimated needs of the Government during the next two years. The appeal was sent out by the Civil Service Commission and was accompanied by estimates of the number of new men that would be required in each special technique.

Thus, in the field of physics, 295 specialists in radio, 304 in meteorology, 110 in ballistics, and 98 other specialists will be needed.

In chemistry 233 experts in explosives, 144 in the metallurgy of manganese, magnesium and aluminum and 179 others will be needed.

In engineering 916 mechanical, 812 industrial, 514 chemical, 443 electrical, 420 aeronautical and 1,355 other engineers will be required. In addition, 1,591 junior engineers, 3,424 engineering aides, and 4,113 engineering draughtsmen will be wanted.

In medicine, 1228 nurses and 636 physicians are required.

Inspectors in all branches to the number of 9,218 will be required and an unestimated number of economists, business analysts, and administrative technicians.

The estimates do not include the number of men that will be needed by civilian industry to replace those drawn off by defense needs or the draft.

MATHEMATICAL EDUCATION FOR DEFENSE*

WILLIAM L. HART
University of Minnesota, Minneapolis

1. *Introduction.* A report of activities and recommendations was recently presented to Professor Marston Morse, Chairman of the War Preparedness Committee, by its Subcommittee on Education for Service. The following extracts differ from the complete report through the omission of certain recommendations which at the moment are not sufficiently matured to be appropriate for publication. All curricular recommendations are included in the following paragraphs.

The active members of the Subcommittee, who subscribe unanimously to the report, are as follows: R. S. Burington; H. B. Curry; E. C. Goldsworthy; F. L. Griffin; W. L. Hart; M. H. Ingraham; E. J. Moulton.

2. *Activities.* Members of the Subcommittee and a few other cooperating mathematicians reviewed or inspected an extensive list of books and pamphlets of a mathematical nature which are employed as text material in service schools of the Army and Navy and in the Civil Aeronautics Program. Personal contacts were established by the Subcommittee with various regular officers of the Army and Navy, teachers in the Civil Aeronautics Program, representatives of the field of secondary mathematics, and certain individuals of experience and reputation in the field of vocational education. In spite of these efforts to obtain an objective foundation for opinions and recommendations, it must be definitely admitted that the need for speedy action, as well as the intangible nature of certain features of the situation, did not permit the Subcommittee to adopt an entirely objective approach. In evaluating evidence and formulating opinions, the Subcommittee was aided by the fact that certain of its members had had military experience during the First World War.

3. *Statement of general view-points.* Mathematicians who are interested in the contacts between their field and emergency problems of national defense and industry should guard themselves against attaching too much importance to the most advanced mathematical aspects of the situation and also too little significance to the elementary or intermediate mathematics which is of use in many directions. It should be realized that, in our nation, which in the past has always been geared to a peace-time economy, with only brief intermissions when military affairs were reckoned of importance, there is likely to be a large element of surprise in the public reaction to information that military science, in most of its important branches, is mathematical in nature. However, in such a statement we do not imply that the mathematics involved is necessarily of *advanced* type. Also, we must be alert to recognize the presence of methods or theory in military and naval science which involve a mathematical *background* for intelligent appreciation, even though, superficially, no mathematical techniques are employed. A similar statement can be made concerning an evaluation of the mathematical needs of industrial workers, below the level of engineers.

In arriving at an estimate of the mathematical background which is *desirable* for workers in government and industry, and for officers and enlisted men in the Army and Navy, we recognize the validity of the following pedagogical viewpoint. *In order that an individual may be able to use effectively any particular body of technique, his school training should extend a*

* Progress Report of the Subcommittee on Education for Service of the War Preparedness Committee of the American Mathematical Society and the Mathematical Association of America.

reasonable distance beyond the level of difficulty at which he will apply the technique. Thus, if we wish to prepare a student so that, later, perhaps after some review, he can use *elementary algebra*, he should be exposed to *advanced algebra*, or to some other mathematical subject with elementary algebra as a prerequisite. This pedagogical view-point is at variance with emergency actions which would attempt to give men the bare minima of mathematical techniques necessary for a *formal* approach to their applications. An emergency justifies *any* remedial action, but our efforts should be directed toward making it unnecessary to use hazy emergency shortcuts to mathematical procedures. With our widespread democratic system of secondary and collegiate education, our nation is justified in demanding that we should always have on hand a relative *surplus* of people with mathematical training through substantial secondary mathematics and also a surplus with elementary college training in the subject.

At this point it is pertinent to remark that, in the remainder of this report, any apparent omission relating to content or training at the graduate level is due to our decision that the omitted matter falls more properly in the spheres of other subcommittees of the War Preparedness Committee.

4. *Recommendations concerning mathematics for those engaged in non-military activities.* The importance of military aspects of the present national emergency should not cause us to lose sight of the equally important mathematical features of the normal and emergency activities of government, the various learned professions, and industry. We observe an enormous expansion in the aircraft and other munitions industries, a continuous drain on the national supply of skilled workers due to Army and Navy calls for enlisted specialists, and the extensive statistical and accounting work associated with our national economy. It is our opinion that these features of the present situation, as well as general underlying trends independent of the emergency, create a need for an increased supply of young men and women with training in mathematics through various levels beyond the junior high school grades. We believe that skilled workers in mechanical industry should have, in their backgrounds, substantial secondary mathematics through the stage of computational trigonometry, and at least an intuitional and *sketching* acquaintance with the fundamental notions of solid geometry. Also, we recommend that increased numbers of men and women should be trained at least through substantial secondary mathematics, to create a reservoir of suitable candidates for positions demanding mathematical skill and for the professions where advanced mathematical knowledge is of advantage. In particular, it would be desirable to have numerous women trained through the stage of elementary mathematical statistics, for the use of government, the professions, and industry. We believe that these recommendations for mathematical training, in so far as they relate to secondary or elementary college mathematics, would not be harmful in connection with other educational objectives dissociated from the field of mathematics.

5. *Evaluation of the mathematical needs of the Army and Navy.* If we ask what the Army and Navy would desire as mathematical training for officers under *ideal* conditions, we obtain a sufficient answer by observing the intensely mathematical and technical nature of the curricula in the academies at West Point and Annapolis. The desirable level of training could be maintained during the present expansion of the Army and Navy only if all the officers, particularly in certain branches, were required to be engineers. We may assume that this ideal obviously is impossible of attainment, if we admit the truth of many authoritative statements that a shortage of engineers exists at present even for the needs of industry alone, apart from the

requirements of the Army and Navy. Our evaluation of the mathematical needs of the Army and Navy will be made in the light of the emergency situation, with a subjective view as to the levels of training which are possible of attainment if full advantage is taken of our extensive educational system. Moreover, we shall give no consideration to mathematical features of the curricula at West Point and Annapolis, because the graduates of those schools obviously have fine training for their activities. We are interested in the mathematical backgrounds of all others, officers or enlisted men, outside of the commissioned personnel of the Regular Army and Navy, who are in or who will enter our Army and Navy. We shall omit mention of various branches of the Army whose activities obviously are non-mathematical. In summary, we believe that the following specifications of mathematical training for *officers* give *minimum* levels, if our Army and Navy are to be intelligently led. The training specified for various enlisted men may exceed the true minimum levels but probably are the *desirable* levels, and we believe that they can be attained. However, these training goals for both officers and enlisted men will *not* be attained unless special efforts are made by the high schools, colleges, civilian centers of adult education, existing service schools of the Army and Navy, and directors of education in the Army and Navy outside their existing schools.

5.1 *Infantry*. Even this supposedly non-technical branch of the Army places demands on mathematics. All enlisted men find use for arithmetic and intuitional geometry and would be benefited by the content presented in modern courses in mathematics for grades eight and nine. The officers, non-commissioned officers, and privates first-class should have familiarity with elementary geometry to permit map reading and construction, appreciation of contour designations, and the use of coördinate systems. They should be able to study intelligently the mechanical drawings associated with the rifles, light anti-aircraft guns, motorized equipment, and other material assigned to them. In brief, these officers and the upper groups among the enlisted men should have as substantial a background in mathematics as we consider desirable for skilled workers in mechanical industry. In addition, the officers would find it useful to have an acquaintance with the notions of probability and probable error as met in elementary statistics, so as to appreciate the theory of gunfire as applied to fire by the infantry and either opposing or supporting fire by artillery.

5.2. *Coast Artillery Corps*. This exceedingly mathematical branch controls all artillery for seacoast defense, high altitude anti-aircraft artillery, and mobile artillery of heavy caliber. The officers of this corps have to perform the duties of surveyors on some occasions, and they deal with very complex optical instruments, motorized equipment, and complicated guns. These men should have very strong training in mathematics; in fact, we hesitate to specify training short of that possessed by graduates of an engineering college. But, as a minimum, these officers should have passed through advanced high school algebra, computational plane trigonometry, enough spherical trigonometry for its typical applications in surveying, and the elements of solid geometry. Also, they should have an acquaintance with the notions of probability and probable error for appreciation of the theory of gunfire. In addition, a substantial number of the enlisted men should be as well qualified mathematically as the officers, so as to provide intelligent personnel for technical groups and to permit the training of enlisted understudies for all the officers as insurance against the effects of casualties. It would be desirable if practically all the enlisted men had the mathematical background which we consider suitable for skilled workers in mechanical industry.

5.3. *Field Artillery*. We make the same minimum stipulations for mathe-

matical training in this branch as in the Coast Artillery Corps, with omission of mention of spherical trigonometry for the officers, and with less insistence on the need for mathematical backgrounds in the case of the enenlisted men.

5.4. *Signal Corps.* The officers should be electrical engineers and the enlisted men should have the mathematical training suitable for skilled workers in mechanical industry.

5.5. *Ordnance Department.* It needs various specialists, among both the officers and the enlisted men, with highly mathematical backgrounds such as possessed by engineering graduates or college majors in mathematics and physics.

5.6. *Ground Force of the Air Corps, in the Army and Navy.* The ground service requires many engineers, men with extensive college mathematics and physics especially for the meteorological section, and a large number of enlisted men and officers with the mathematical backgrounds suitable for skilled mechanical industry.

5.7. *Pilots or navigator-gunners in the Air Corps of the Army and Navy.* They should be acquainted with plane trigonometry, the elements of solid geometry, and an introduction to spherical trigonometry. They need this content for the study of navigation, elementary aerodynamics, bombing, meteorology, and various other technical subjects. The importance of space concepts and physical reasoning in three dimensions in such subjects adds to the importance of solid geometry for this group of men. Very substantial manipulative algebra is needed by them and we presume that this is included as a prerequisite for the trigonometry course. Moreover, they should have acquaintance with the notions of probability and probable error to aid in the appreciation of certain aspects of the theory of bomb dropping.

5.8. *Officers of the Navy, outside of its Air Corps, and officers of the Merchant Marine.* We hesitate, again, to specify training short of a college degree in some field of engineering. As an emergency minimum, however, we recommend that these men should have the mathematical background specified for pilots in the Air Corps, with additional emphasis on algebra and spherical trigonometry. We include reference to officers of the Merchant Marine in our remarks because of its general importance and also its complementary relationship to the Navy in time of war.

5.9. *Enlisted men in the Navy.* They should have the mathematical background desirable for skilled workers in mechanical industry. In addition, a substantial number of these enlisted men should be as well qualified mathematically as the officers, to provide intelligent personnel to serve in technical groups and as understudies for officers.

6. *Conclusions drawn from results of the program of reviews of books of a mathematical nature used by the Army, Navy, and Civil Aeronautics Authority.*

6.1. By and large, the mathematical exposition in these books is satisfactory, particularly when we take account of the fact that they are intended for readers with a minimum technical background. The reviews do not justify us in calling for prompt revisions of any of the existing text material, although various criticisms of present expositions could be made.

6.2. We believe that any one of these books can be well appreciated by a reader who has a proper mathematical background, in accordance with our preceding recommendations, and a suitable teacher. This opinion permits the Subcommittee to place its main emphasis, *first,* on the preceding recommendations for mathematical backgrounds, and, *second,* on an analysis of the effects of these recommendations on plans for instruction in the civilian and military educational system.

7. *Recommendations concerning the field of secondary mathematics.*

7.1. In the secondary field, it would be very undiplomatic and harmful if the national emergency were taken as an excuse for a violent attack on certain curricular trends, even though weaknesses of some of these trends may become apparent when they are analyzed under the search-light of present national necessities. We consider it best to state mathematical objectives without stipulating the pedagogical details to be involved in their attainment.

7.2. The National Council of Teachers of Mathematics and all organized bodies of teachers of mathematics at the secondary level should advertise the utility of mathematics in industry, government, the professions, and military science.

7.3. In high schools it should be advertised that the Navy R.O.T.C. and the Coast Artillery groups of the Army R.O.T.C. in colleges require trigonometry as a prerequisite and that they should require the elements of solid geometry and spherical trigonometry. Also, it should be emphasized that these subjects can be studied efficiently in high school.

7.4. In the junior and senior high schools, each boy and girl *of sufficient mathematical aptitude* should be urged by his advisers to observe that the study of mathematics through the stage of trigonometry and some solid geometry may serve as a distinctly patriotic action.

7.5. We recommend that, in connection with emphasis on so-called *socialized* aspects of secondary curricula, a liberalized definition of *socialized mathematics* should be adopted for students at all ability levels, in contrast to more narrow definitions which give unique prominence to business applications and consumer interests. In the liberalized definition we would emphasize that content with military, scientific, professional, and industrial uses is of a most socialized nature. Also, from the standpoint of a high school student of intelligence, *classical* mathematical content may be very "*socialized*," in a true sense, even though the content possesses only *delayed* utility, as contrasted with *immediate* utility in the student's experience.

7.6. The military, industrial, and scientific utility of a considerable quantity of space intuitions and at least a little spherical trigonometry, causes us to recommend that the high school work in solid geometry, both intuitional and demonstrative, be given more prominence than in recent years. The classical course in solid geometry might be modified by replacing some of its content with a treatment of the elements of spherical trigonometry. Or, the intuitional and demonstrative plane geometry presented in grades eight through ten might be modified to include sufficient material from solid geometry.

7.7. We *strongly* recommend that a *single* set of courses be used in any high school for students of *appropriate ability* in attaining desired ends relating to industry, military service, or future collegiate education. We recommend this single treatment rather than separate curricula, some designed to fit men for industry or military service and some planned for those who will delve more deeply into mathematics and related fields in college. In the case of superior students, substantial mathematics, fitted to their intelligence, is likely to serve them better, whenever they will use mathematical content, than specifically pointed vocational mathematics or military mathematics. Thus, we argue against a curricular division in mathematics among secondary students which would be based on their present economic status, their *momentary* expectations about attending or not attending college, or *transient* vocational preferences, and we advise instead a curricular division based on the *intelligence* of the students.

7.8. As a temporary measure, we recommend that boys of intelligence who now are in grades 11 and 12 and who have previously omitted substan-

tial mathematics, should be offered an abbreviated treatment of logarithms, plane trigonometry, intuitional solid geometry, and perhaps an introduction to spherical trigonometry, to train them for their practically certain entrance into skilled industry, the Army, or the Navy.

7.9. We advise the evening schools in cities to give new emphasis to courses in advanced high school mathematics through the stage of trigonometry.

7.'10. We advance the opinion that a shortage of engineers and physicists is at hand. This should be brought to the attention of boys of mathematical ability in the high schools; if these boys extend their exposure to secondary mathematics but later fail to become engineers or physicists, their mathematical training will have sufficient general utility to justify our recommendation.

7.'11. At all stages of secondary mathematics we recommend emphasis on applications. However, the teacher and student should not anticipate that all these applications, or even a majority of them, will be of intrinsically natural types. The pedagogical aim in this connection should be to convince the student that mathematics has not only important cultural and theoretical sides but also is intensely *useful* in our civilization; the applications, artificial or real, should give the student experience and confidence in applying general mathematical techniques as auxiliaries in related fields.

8. *Curricular recommendations at the college level.*

8.1. We wish to re-emphasize an early recommendation of the War Preparedness Committee by suggesting that as many college teachers of mathematics as possible should carry out measures of self-instruction in one or more of the following fields: Hydrodynamics; Aerodynamics; Meteorology; Probability and Statistics; Computation; Industrial Applications of Mathematics; Exterior Ballistics; Navigation; Artillery Fire Control and Orientation; Cryptanalysis. An enlarged background in these fields would be useful to the teacher of college mathematics at any time and, at this moment, would aid him in introducing problems of emergency interest into his routine courses. Also, such self-instruction would prepare the teachers for emergency use in directions where their talents would be of advantage. Those interested in such self-instruction should consult the bibliography published in the "Report of the War Preparedness Committee," *Bulletin of the American Mathematical Society*, vol. 46, 1940, page 713.

8.2. We consider it justifiable for the Department of Mathematics in any college to introduce undergraduate courses in hydrodynamics and aerodynamics, and courses in meteorology in conjunction with the Physics Department, in case such courses are not being given by other departments.

8.3. We recommend a course in exterior ballistics, with a prerequisite of at least elementary calculus and a first course in differential equations, for consideration in the organization of work in applied mathematics.

8.4. We suggest that, in the senior college years, a combination field of major concentration in mathematics and its applications be provided by the Department of Mathematics and the Departments of the Physical Sciences, perhaps in collaboration with the Departments of Engineering if they are present in the college. Such an undergraduate major might involve some sacrifice of pure mathematical content as compared with a narrow major in mathematics. If the curriculum were organized on a five-year basis, through cooperation between Mathematics, Physics, Chemistry, and Engineering, the curriculum would offer training which could be very useful in industry.

8.5. We wish to caution Departments of Mathematics to avoid indiscriminate introduction of elementary courses in *war* mathematics. In par-

ticular, we do not consider it desirable to suggest any special course pointed at Army or Navy service which does not have at least plane trigonometry and substantial manipulative algebra as a prerequisite. This opinion is due to our conviction that the classical material just mentioned is more valuable than a preliminary exposure, with a weak foundation, to military and naval applications in advance of their later study while in service in the Army or Navy. Moreover, we observe with satisfaction that the Army and Navy, in certain directions, are giving explicit credit in priority ratings to men with credit in *classical* courses in trigonometry and advanced algebra, and also in more advanced mathematics. Hence, for any given group of students, we recommend that a Department of Mathematics should carefully investigate the relative advantages of *more classical mathematics* as compared to any *emergency* course in war mathematics before it is introduced.

8.6. For certain special groups of students, we recommend consideration of the following emergency courses, with plane trigonometry and college algebra as prerequisites:

8.61. For students who are fairly sure that they will enter the Air Corps, the Navy, or the Merchant Marine: a course in navigation, including necessary spherical trigonometry and solid geometry.

8.62. For students who are fairly sure to enter the Air Corps, the Navy, or the Coast Artillery Corps of the Army: a brief course, to be offered two hours per week for three months, in the elements of solid geometry and spherical trigonometry.

8.63. For students who plan to enter the Army or the Navy in any capacity and who wish a review of probably useful material with moderate additions: a semester course, to be offered three or four hours per week, which will present, *first*, a review of geometry, necessary algebra, logarithms, and trigonometry, with emphasis on its numerical aspects, and, *second*, new material relating to solid geometry, spherical trigonometry, and probability as involved in the theory of gunfire and bombing. We recommend this semi-review course for use in college extension curricula and in evening schools, as well as in daytime college work.

8.7. We suggest only the following moderate modifications in standard courses:

8.71. Considerably increased emphasis on applications and computational techniques; in this connection the teacher could bring to bear his extended background as advised in Section 8.1.

8.72. In trigonometry, the inclusion of a treatment of mil measurement (the Army system of angular measure), emphasis on vector language and applications, and, for certain students, an expansion of the course to include some spherical trigonometry in colleges where that subject is not usually taught.

8.73. In college algebra, expansion of the work in probability to include introduction of the normal probability curve, the general notion of a frequency curve and its probability significance, and use of the language of probable error.

8.8. We recommend that women who are studying college mathematics be given a course in mathematical statistics with at least freshman mathematics as a prerequisite, regardless of the individual educational objectives of these students. In addition to broadening their backgrounds for their peace-time vocations, this work in statistics might prove useful to the women in search for employment in present emergency activities.

8.9. We suggest that each Department of Mathematics canvass the situation of young men and women in its college who have mathematical talent, even though they may not be taking courses in college mathematics.

The men should be made acquainted with existing opportunities for preference in the Army and Navy as the result of training in mathematics. The women should be informed of those semi-mathematical fields, for instance, business statistics, accounting, and drafting, where a continued drain on available man power may create openings for women.

8.'10. Regardless of justified attitudes which cause colleges to avoid teaching elementary parts of secondary mathematics, we recommend that each Department of Mathematics should do everything in its power to aid interested college men, or high school graduates not in college, in learning secondary mathematics which will be of use to them in the Army or Navy. Such instruction could be offered through extension or correspondence courses, as well as in daytime classes, and should be arranged so as to avoid duplication with efforts of neighboring high schools.

8.'11. If a Department of Mathematics has taken all appropriate actions in accordance with the preceding Sections 8.2 through 8.'10, with particular attention paid to the cautions of Section 8.5, and in addition desires to provide a general elementary course in war mathematics, the following outline by Professor Griffin may be useful. This outline gives a rounded view of typical applications of mathematics in military and naval science which should interest men and women alike and which would have specific utility for men who will enter the Army or Navy. The content could be taught well only by one who has an extensive background gained either through actual service in the Army or Navy, or by study as suggested in Section 8.1.

WAR MATHEMATICS

(Three hours per week for one year; suggested by F. L. Griffin)

Pure Mathematical Topics

Chapter I. Preliminary Ideas.
II. Trigonometric Functions.
III. Logarithmic Calculations.
IV. Coordinates and Notions from Analytic Geometry.

Artillery and Machine Gun Problems

Chapter V. Position Calculations. Methods of locating a fixed target: by direct observation; indirect observation involving trigonometry; map location; sound methods.
VI. Ballistic Calculations. Initial firing data; adjustment of fire; probable errors; bracketing; effect of fire; velocity and angle of impact; penetration.
VII. Safety Zones and Dead Areas.
VIII. Barrage Fire.
IX. Theoretical Ballistics. Discussion of the construction of firing tables.

Army Engineering Problems

Chapter X. Graphical Methods; Rates; Maxima; Work; Momentum.
XI. Statics; Bridge Structures; Cranes; Inclined Planes.
XII. Flexure of Beams; Suspension Cables.

Aviation Problems

Chapter XIII. Principles of Flight. Stability; Equilibrium.
XIV. Bombing.

XV. Spherical Trigonometry and Navigation.

NOTE. For further information concerning the preceding course, consult Professor F. L. Griffin, Reed College, Portland, Oregon.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1717. *Proposed by Julius Freilich, Brooklyn, N. Y.*

If quadrilateral $ABCD$ be inscribed in a circle, radius R, center O, with AB and DC meeting at E: AD and BC meeting at F, prove by elementary geometry that

$$\overline{EF}^2=\overline{OE}^2+\overline{OF}^2-2R^2.$$

Solution by Paul D. Thomas, Norman, Oklahoma

From the points F and E draw respectively the tangents FG and EH to the circle. Draw the bisectors of angles AFB and AED. These bisectors meet in K. It is known that angle EKF is a right angle, and that $EH=EK$, $FG=FK$. Hence

$$\overline{FK}^2+\overline{EK}^2=\overline{EF}^2=\overline{EH}^2+\overline{FG}^2. \tag{1}$$

Now

$$\overline{EH}^2=\overline{OE}^2-R^2 \tag{2}$$

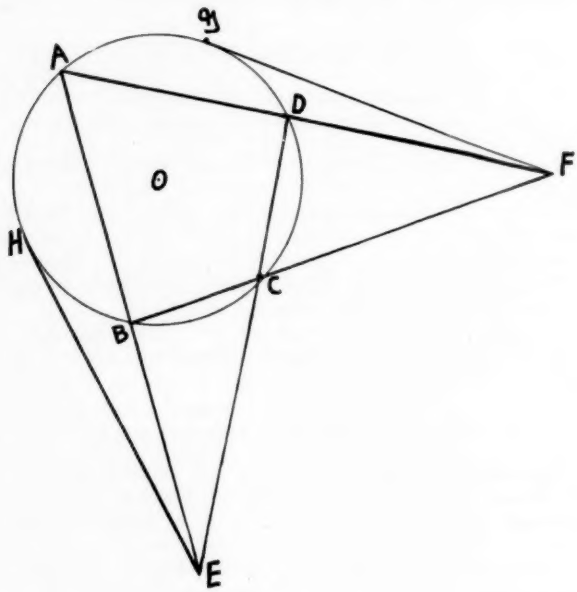
$$\overline{FG}^2=\overline{OF}^2-R^2. \tag{3}$$

Add (2) and (3) to get

$$\overline{EH}^2+\overline{FG}^2=\overline{OE}^2+\overline{OF}^2-2R^2,$$

but by (1)

$$\overline{EF}^2=\overline{EH}^2+\overline{FG}^2=\overline{OE}^2+\overline{OF}^2-2R^2.$$



Editor's Note:—The relation given in (1), namely $\overline{EF}^2=\overline{EH}^2+\overline{PS}^2$ will be given as problem 1759 to be proven in a later issue.

Solutions were also offered by John Hoyt, Cornwall-on-Hudson, New York; Hugo Brandt, Chicago; and the Proposer.

1718. *Proposed by John P. Hoyt, Cornwall, New York* .

In triangle ABC, if D divides CB so that $CD/DB=m/n$, then

$$\overline{AD}^2=\frac{nb^2}{m+n}+\frac{mc^2}{m+n}-\frac{mna^2}{(m+n)^2}\cdot$$

Solution by David X. Gordon, Brooklyn, New York

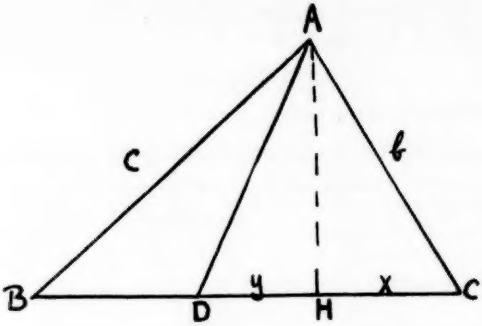
$$\overline{AD}^2=\overline{AH}^2+\overline{HD}^2=b^2-x^2+y^2=b^2+(y+x)(y-x)=b^2+(y+x)(y+x-2x)$$
$$=b^2+(y+x)^2-2x(y+x)$$

From the figure,

$$y+x=\frac{ma}{m+n} \quad\text{and}\quad x=\frac{b^2+a^2-c^2}{2a} \quad\text{from } c^2-[a-x]^2=b^2-x^2.$$

By substitution,

$$\overline{AD}^2=b^2+\left(\frac{ma}{m+n}\right)^2-\frac{m(b^2+a^2-c^2)}{m+n}=b^2\left[1-\frac{m}{m+n}\right]+\frac{mc^2}{m+n}+\frac{ma^2}{m+n}\left[\frac{m}{m+n}-1\right]$$
$$=\frac{nb^2}{m+n}+\frac{mc^2}{m+n}-\frac{mna^2}{(m+n)^2}\cdot$$



$$BD = \frac{na}{m+n}, \quad DC = \frac{ma}{m+n}$$

Solutions were also offered by Lucio Chiquito, Medellin, Colombia, South America; John P. Hoyt, Cornwall-on-Hudson, New York; Paul D. Thomas, Norman, Oklahoma; C. W. Trigg, Los Angeles City College; Robert E. Anspaugh, Evanston, Illinois; D. F. Wallace, Minnesota; Brother Felix John, Pittsburgh, Pennsylvania; Hazel White, East Varick, New York; Anna V. Wilson, Interlaken, New York; W. R. Warne, Rochester, New York; and May Haggerty, McDuffietown, New York.

1719. *Proposed by Stephen Droemus, Willard, New York*

If a number is both a square and a cube, show that it is of the form $7n$ or $7n+1$.

Solution by John P. Hoyt, Cornwall-on-Hudson, New York

If a number is both a square and a cube, it can be expressed as m^6. Now m is either prime to 7 or it is not. If it is not prime to 7, m^6 is of the form $7n$. If m is prime to 7, m^6-1 is a multiple of 7 by Fermat's theorem. Hence, m^6 is of the form $7n+1$.

Solutions were also offered by Jean Andres Thomas, Norman, Oklahoma; C. W. Trigg, Los Angeles City College; Robert E. Anspaugh, Evanston, Illinois; David X. Gordon, Brooklyn, New York; Brother Felix John, Pittsburgh, Pennsylvania; Lucio Chiquito, Medellin, Colombia, South America.

1720. *Proposed by Frank C. Brady, Seneca Falls, New York*

Find the sum of the fourth powers of the roots of

$$x^3-2x^2+x-1=0.$$

First solution by Arthur Danzl, Collegeville, Minnesota

Calling the roots a, b, c, we then have:

(1) $$a+b+c=2$$

(2) $$ab+ac+bc=1$$

(3) $$abc=1.$$

Squaring (1) we have $a^2+b^2+c^2+2(ab+ac+bc)=4$ or

(4) $$a^2+b^2+c^2=2.$$

Squaring (4) we get (5) $a^4+b^4+c^4+2(a^2b^2+a^2c^2+b^2c^2)=4$.

Squaring (2), $a^2b^2+a^2c^2+b^2c^2+2abc(a+b+c)=1$ or $a^2b^2+a^2c^2+b^2c^2=-3$. By substitution in (4)

$$a^4+b^4+c^4=10.$$

Second solution by David X. Gordon, Brooklyn, New York

(1) $$a^4+b^4+c^4=(a+b+c)^4-4(a+b+c)^2(ab+bc+ca)+2(ab+bc+ca)^2$$
$$+4abc(a+b+c)\quad a+b+c=2$$
$$ab+bc+ca=1$$
$$abc=1$$

and by substitution in (1)

$$a^4+b^4+c^4=10.$$

Solutions were also offered by Brother Felix John, Pittsburgh, Pennsylvania; Kenneth P. Carlson, Hershey, Nebraska; Frank C. Brady, Seneca Falls, New York; C. W. Trigg, Los Angeles City College; John P. Hoyt, Cornwall-on-Hudson, New York; Walter R. Warne, Rochester, New York; Lucio Chiquito, Medellin, Colombia, South America.

1721. *Proposed by Antonio Tudeno, Lakemont, New York*

Solve the equations

$$x^{x+y}=y^4$$
$$y^{x+y}=x.$$

Solution by Paul Thomas, Norman, Oklahoma

Substituting from the second into the first of the given equations gives

$$y^{(x+y)^2}=y^4,$$

whence

(1) $$x+y=\pm 2.$$

For $x+y=2$, the second of the given equations becomes $y^2=x$. For $x+y=-2$, the second of the given equations becomes $xy^2=1$. Thus the problem reduces to the solutions of

(2) $$x+y=2$$
$$y^2=x$$

and

(3) $$x+y=-2$$
$$xy^2=1.$$

The solutions of (2) are readily seen to be $(4, -2)$, $(1, 1)$. The solutions of (3) depend upon the solutions of the cubic

(4) $$y^3+2y^2+1=0.$$

If the transformation $y=(z-2)/3$ is used, (4) becomes

(5) $$z^3-12z+43=0.$$

Using Cardan's formula, the roots of (5) are

$$z_1=\sqrt[3]{A}+\sqrt[3]{B},\qquad z_2=w\sqrt[3]{A}+w^2\sqrt[3]{B},\qquad z_3=w^2\sqrt[3]{A}+w\sqrt[3]{B},$$

where w, w^2 are the conjugate complex cube roots of unity and $A=\frac{1}{2}(3\sqrt{177}-43)$, $B=-\frac{1}{2}(3\sqrt{177}+43)$. Hence the solutions of (3) are

$$\begin{cases} x_1 = -2-(\sqrt[3]{A}+\sqrt[3]{B}-2)/3 \\ y_1 = (\sqrt[3]{A}+\sqrt[3]{B}-2)/3, \end{cases} \qquad \begin{cases} x_2 = -2-(w\sqrt[3]{A}+w^2\sqrt[3]{B}-2)/3 \\ y_2 = (w\sqrt[3]{A}+w^2\sqrt[3]{B}-2)/3, \end{cases}$$

$$\begin{cases} x_3 = -2-(w^2\sqrt[3]{A}+w\sqrt[3]{B}-2)/3 \\ y_3 = (w^2\sqrt[3]{A}+w\sqrt[3]{B}-2)/3. \end{cases}$$

Solutions were also offered by John P. Hoyt, Cornwall-on-Hudson; C. W. Trigg, Los Angeles College; David X. Gordon, Brooklyn, New York; H. M. Zerbe, Wilkes-Barre, Pa.; Mattie Tobias, Bearytown, New York; Robert E. Anspaugh, Evanston, Illinois; Brother Felix John; Joseph M. Synnerdahl, Chicago, Ill.; Walter R. Warne, Rochester, New York.

1722. *Proposed by an Old Subscriber*

If S is the sum of the first n terms of the sequence $1, 1+k, 1+2k, \ldots,$ where k is a positive integer and if S_3 is the sum of the cubes of the same terms, show that S_3 is divisible by S_1.

Solution by Howard D. Grossman, New York City.

$$\frac{\sum_{k=0}^{n} (a+kb)^3}{\sum_{k=0}^{n} (a+kb)} = \frac{\sum_0^n a^3 + 3\sum_0^n a^2bk + 3\sum_0^n ab^2k^2 + \sum_0^n b^3k^3}{\sum_0^n a + \sum_0^n bk}$$

$$= \frac{a^3(n+1)+3a^2bn(n+1)/2+ab^2n(n+1)(2n+1)/2+b^3n^2(n+1)^2/4}{a(n+1)+bn(n+1)/2}$$

$$= a^2+abn+b^2n(n+1)/2,$$

which is always integral.

Solutions were also offered by Brother Felix John, Pittsburgh, Pa.; C. W. Trigg, Los Angeles City College; John P. Hoyt, Cornwall-on-Hudson; Robert E. Anspaugh, Evanston, Ill.; David X. Gordon, Brooklyn, New York; Lucio Chiquito, Medellin, Colombia, South America.

STUDENT HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted to this department. Teachers are urged to report to the Editor such solutions.

No solutions were offered.

PROBLEMS FOR SOLUTION

1735. *Proposed by Celia Miller, Interlaken, N. Y.*

If the ex-circle of triangle ABC, which is tangent to BC, equals the circumcircle, show that $\cos A = \cos B + \cos C$.

1736. *Proposed by Ethel Kunes, Starkey, N. Y.*

In an oblique triangle ABC; if $C = 60°$, show that

$$\frac{1}{a+c} + \frac{1}{b+c} = \frac{3}{a+b+c}.$$

1737. *Proposed by Ethel Kunes, Starkey, N. Y.*

In any triangle if H is the ortho-center, show that $AH = 2R \cos A$, where R is the circum-radius.

1738. *Proposed by Nellie E. Walters, Canoga, N. Y.*

If a, b, c are sides of a triangle show that

$$\left(1+\frac{b-c}{a}\right)^a \left(1+\frac{c-a}{b}\right)^b \left(1+\frac{a-b}{c}\right)^c < 1.$$

1739. *Proposed by J. S. Bodine, Phoenix, Ariz.*

If the roots of $ax^2+2bx+c=0$ be real and different, those of $(a+c)(ax^2+2bx+c)=2(ac-b^2)(x^2+1)$ will be imaginary and vice versa.

1740. *Proposed by David X. Gordon, Brooklyn, N. Y.*

Eliminate m from the equations

$$y=mx+\sqrt{a^2+b^2m^2}$$

$$y=\frac{x}{m}+\sqrt{a^2+\frac{b^2}{m^2}}\,.$$

SCIENCE QUESTIONS

November, 1941

Conducted by Franklin T. Jones,
10109 Wilbur Avenue, SE, Cleveland, Ohio

Contributions are desired from teachers, pupils, classes and general readers. Send exmination papers from any source whatsoever, questions on any part of the field of science, tests, questions having to do with the pedagogy of science —in fact, anything that appeals to the reader or might appeal to other readers; also, anything that will help to make the subjects arrayed under SCIENCE more useful or more interesting to teachers and pupils. Select your own topic. It will, most likely, be interesting to others.

We will endeavor to get answers to all reasonable questions. It is always valuable to get questions whether they can be answered or not.

Contributors to SCIENCE QUESTIONS are accepted into the GQRA (Guild of Question Raisers and Answerers).

Classes and teachers are invited to join with others in this co-operative venture in science.

INTEREST RAISERS IN ELEMENTARY SCIENCE

Please try the following questions on a class—whether of the same age as the pupils who proposed them or some other age.

If you like, send some of the original papers of the pupils answering, either from one pupil for the entire list or separate questions and answers from individuals.

Teachers are invited to get their classes to submit sets of questions and answers for this series.

QUESTIONS ASKED BY AN EIGHTH GRADE BOYS' CLASS

(*Elected to the GQRA, No. 370, Public School No. 54, Indianapolis, Ind.*)

Answers are desired from some other class, or from individuals.

(1)—What makes a lightning bug light?

(2)—What makes an airplane stay in the air?

(3)—Why can't we get perpetual motion?
(4)—What is the difference between planets and planetoids?
(5)—What causes tornadoes?
(6)—Why are summer days longer than winter days?
(7)—What is compressed air?
(8)—In a gear box of a car, how does it work so that one wheel will rotate faster than the other in going around a curve?
(9)—Why does not a magnet attract silver coins?
(10)—Why can't we see through glass?
(originally published as 924)

Hints to find answers

(1)—Look under Glow Worm in Encycl. Britannica.
(2)—Ask an aviator.
(3)—Ask your teacher.
(4)—Look in any book on astronomy or in the dictionary.
(5)—Your book on General Science should tell you. If not there, look in any book on Weather.
(6)—Explain the Change of Seasons and you have the answer.
(7)—Go to a garage and to see the air compressor and figure it out for yourself. You use it in auto tires and your bicycle tires.
(8)—This is a hard one. Perhaps an auto mechanic can explain.
(A Professor of Auto Mechanics in a large university came to the shop where I was once Supervisor of Training and wanted to see the Rear Axle Dept. He watched the assembly of a *Differential*, had its operation explained to him by the Foreman, said he understood and then confessed that he "had taught Auto Mechanics to engineering students for 12 years, including the action of the differential, but *never had understood how it worked!*" FTJ)
(9)—See Dict. definitions of *Magnet* and *Magnetic Substance*. Is silver either one?
(10)—Query—Should this be stated—"Why can't we see through all glass?"

(*These hints are given to show how simple it usually is to locate answers to questions that arise.* Editor.)

QUESTIONS USED IN ENGLAND

931. (*Quite some years ago there came into the Editor's possession a copy of "A BOOK OF EVERYDAY" published by Relfe Brothers, Ltd., London. Part I is entitled "House and Home"; Part II, "Rights and Duties; Locomotion." It is a Social Science-General Science reading book for young pupils*). *The following questions appear in connection with Chapter xvii.*
(1)—Give an account of man's early efforts to fly. In what way is a balloon different from a man-lifting kite?
(2)—Why is a motor car engine called an "internal combustion" engine?
(3)—What advantages over single cylinder engines are possessed by engines of four or six cylinders?
(4)—In what way has the coming of the motor car affected the roads and villages of England?
(5)—How is it that men do not, now that flying machines are so perfected and so commonly used, fly from Liverpool to New York? How does this question fix the date when "*A BOOK OF EVERYDAY*" was published?)

(6)—Jules Verne and H. G. Wells tell of men travelling from the earth to the moon, but neither writer makes his adventurers use a flying machine. Why is this?

Answers and comments are requested. Try these questions on pupils of any age.

WEIGH YOUR FATHER'S AUTO

932. *Proposed by W. E. Harmish, College of Education, University of Illinois High School, Urbana, Ill. (GQRA, No. 354).*

Here is a problem that my Physics classes always find interesting.

"Given four sheets of carbon paper, graph paper, a jack and a tire gauge, how can you weigh your father's auto?"

("*The key is simply this: if the auto weighs 3300 lb. and the tire gauge reads 33 lb. the tires would make an imprint of 100 sq. in. on the graph paper.*")

Classes try this out and report results. Thanks!

CHEMISTRY—REASONING TEST

933. *Prepared by Harold Wm. Baker, James Ford Rhodes High School, Cleveland, Ohio (Elected to the GQRA, No. 408).*

1. What are the valences of an element Q as it forms the following compounds? (a) H_3Q, (b) H_2QO_4, (c) Q_2O_5, (d) KQO_4, (e) Q_3O_4.
2. What is the atomic weight of the element Q if the molecular weight of H_2QO_4 is 282?
3. What is the atomic weight of the element Q if 11.2 liters of vaporized Q_2O_5 would weight 256 grams under standard conditions of temperature and pressure?
4. What is the combining weight of Q in Q_2O_5? (Just write the number of the best answer).
5. From these data, what might you assume about the element as to the term which best describes how it acts: (1) amorphous (2) metallic (3)allotropic (4) non-metallic (5) amphoteric.
6. To which of these is its action most similar? (1) sodium (2) magnesium (3) iron (4) manganese (5) sulfur.
7. To which of these families of elements is its action most similar? (1) calcium (2) potassium (3) phosphorus (4) chlorine (5) iron.

TEN MILES A MINUTE

(*A little preliminary figuring—60 miles an hour is the same as a mile a minute or 88 feet per second. Then ten miles a minute is 600 miles an hour or 880 feet per second.*)

From "News and Views" of General Motors, February, 1941.

On January 8, 1941, at Buffalo Airport, Lieutenant Andrew C. McDonough, U. S. Naval Reserve Corps flier and pilot on Eastern Airlines' Miami-Chicago run, set a new record of 620 miles an hour while testing an Allison-powered Bell Standard P-39 Airacobra interceptor plane.

His exact speed was 909 feet per second, and, when compared with the muzzle velocity of a .45 calibre pistol bullet of 802 feet per second, he was literally travelling faster than the charge of the old six-shooter.

At 27,000 feet the thermometer read 33 below zero. A movie camera focused on the faces of the altimeter, air-speed indicator, clock and

thermometer recorded the necessary figures for the dive. So it was quite some time after the dive was completed before the pilot knew that a record had been broken.

The dive was made with a production ship carrying full military load, which includes a .37-millimeter cannon, two .30 and two .50 calibre machine guns.

The previous record was 575 miles per hour, established by H. Lloyd Child, Curtiss-Wright chief test pilot, diving with the now obsolete Curtiss-Hawk 75 for the French Army.

At 450 miles per hour "air has the same consistency as water."

KEEPING UP WITH INDUSTRY

919. *Asked in April, 1941: Partly answered by STEEL QUIZ, No. 930, in October. Partly answered by the following, No. 934, in November.*

934. *The Optical Industry*
Reading of "THE EDUCATIONAL FOCUS," Fall, 1941, The Bausch & Lomb Optical Co., Rochester, N.Y., suggests the following questions. (Answers follow the questions.)

(1)—What is the Workman illustrated on the Cover page doing?
(2)—When and by whom was the dictum laid down—"*Rays issue from the eye and proceed in straight lines a certain distance apart*"? (page 5). (Have your pupils modernize this dictum.)
(3)—When and by whom were the present foundations of our knowledge of light laid down? What was the classical experiment? (p. 5)
(4)—What is the extent of the Visual Spectrum? (Illustration, page 7.)
(5)—What is the extent of the Explored Radiation Spectrum? (p. 7)

Answers

(1)—The workman is testing optically the contour of teeth on the hobbing cutter in the Contour Measuring Machine before him. Routine measurements can be made to 0.0001″ (one ten-thousandth of an inch). (page 12).
(2)—Some 2200 years ago by Euclid.
(3)—1666 A.D. by Sir Isaac Newton. His experiment was the resolution of the colors of sunlight by passing the light through a prism.
(4)—The visual spectrum extends from just beyond 8,000 to just below 4,000 Angstrom units (in wave lengths 0.0004 to 0.0007 millimeters.)
(5)—The explored radiation spectrum extends from 3×10^{14} to .0001 Angstrom units. (See illustration, page 7.)

Keep Up With Industry by Reading such publications as "The Educationa' Focus," B & L, Rochester, N.Y.

ANSWERS to PROBLEMS

925. *Proposed by J. M. Synnerdahl (GQRA, No. 129) at St. Xavier College, Chicago, Ill.*

"A button is suspended by a thread in a clear glass bottle. The cork is sealed in the bottle. Sever the string so that the button falls; but do not uncork or break the bottle."

Answer: Hold the bottle in bright sunlight, and burn the string with the aid of a convex lens (burning glass).

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926. *Proposed by J. Russell Bright (GQRA, No. 360), Wayne University, Detroit, Mich.*

Chemistry—Homework 1.

"Consider all the following statements for they are helpful in a correct solution of the problem.

"Five gaseous elements are under consideration (A, B, C, D, and E).

(1)—A combines easily with all elements listed except B.
(2)—A combines with C to yield a compound which is 17.6% A and 82.4% C.
(3)—B, C, and D are present in the air.
(4)—D is more electronegative than E.
(5)—A reacts with C, D, and E to form typical co-valent hydrides.
(6)—The weight of 22.4 liters of E is 70.92 grams.
(7)—The density of B is approximately 100% greater than A.
(8)—D has six L electrons.
(9)—The molecular weight of C is $12\frac{1}{2}$% less than that of D.
(10)—D is heavier than air.

"I. Write the formula for each element.
II. Illustrate or explain each of the above ten statements.
III. Make a schematic diagram showing an electronic structure for each element.
IV. What is the commercial source of each?
V. Prepare a table showing physical properties and uses of the element."

Answer to I—The formula of each is—

$$A—H_2;\ B—He;\ C—N_2;\ D—O_2;\ E—Cl_2.$$

The answers to the other parts of the question can readily be supplied by the reader.

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927. *The Grocer's Home-made Scales*
Borrowed from THE DOUBLE BOND'S "Brain Teasers."

This is one that appeared in the PIONEER some time ago.

"A grocer, who was quite handy with tools, made himself a balance scale for use in the store. He was extremely proud of his handiwork until he started to use it.

A customer had picked out a certain ham and asked to have it weighed. The grocer put it in the left pan and balanced it with weights in the right hand pan. The weight of the ham was found to be 7 lb.

The customer was somewhat suspicious of the scales so the grocer sought to prove their accuracy by weighing the ham on the other pan. Now the ham weighed 9 lb. 2 oz.

The grocer then took the pans to another store and found that they weighed exactly one pound. With this information he then went back and calculated the weight of the ham. What was it?"

An answer—One answer given is 8 lb. 1 oz. Is it right?

FLOWERS IN SICK ROOM

929. *Proposed by W. Ming Foo (GQRA, No. 405), Rodney Wilson High School, St. Johns, Michigan.*

"In my eleventh grade chemistry class the teacher encourages us to bring in outside subjects of interest.

"Somehow we got into a discussion of why flowers are taken out of a sickroom at night. Between us, we managed to give a few plausible answers, but most of them were not entirely satisfactory.

"Therefore, I am writing you for the scientific reason for removing flowers from sick rooms."

Answer by Dr. Franklin J. Bacon, Professor of Botany, Western Reserve University, Cleveland, Ohio (Elected to the GQRA, No. 409).

Actually, when they are in the light, as a result of their photosynthetic action, plants give off oxygen and take in carbon dioxide. In the dark they take in oxygen and give off carbon dioxide. In the daylight the balance is in favor of oxygen and in the night in favor of carbon dioxide. However, unless the room is very small and the plant large, the effect of the plant upon the composition of the air is very small.

ANCIENT EGYPTIANS AND THE SIMPLE MACHINES

935. *From THE NATIONAL GEOGRAPHIC MAGAZINE, October, 1941.*

Study the Color Plates of "Daily Life in Ancient Egypt" (pp. 436–514), and see what mechanical devices were used by the Ancient Egyptians. What "simple machines" were known to the Egyptians?

GQRA—NEW MEMBERS—November, 1941

408. Harold Wm. Baker, James Ford Rhodes High School, Cleveland, Ohio

409. Dr. Franklin J. Bacon, Professor of Botany, Western Reserve University, Cleveland, Ohio

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JOIN THE GQRA!

BIGGEST RESEARCH JOB FOR DEFENSE USED 150 SCIENTISTS

One of the most extensive jobs of scientific research in the defense effort took 150 different physicists from 25 different universities to the Massachusetts Institute of Technology's Radiation Laboratory to work on "a highly confidential and important subject with the greatest possible speed," President James Bryant Conant of Harvard, Chairman of the National Defense Research Committee, revealed in a phonographically recorded message sent to the "Science and the New World Order" conference of the British Association for the Advancement of Science in London.

Approximately 1000 scientists are at work for the NDRC in universities and 700 in industrial laboratories, Dr. Conant said. Three-quarters of the most distinguished research physicists of the nation are now at work on war problems, he added, and the remaining 25% will be at work in a few months.

"We have found that the nature of the problems in this present war are such that physicists and certain types of engineers are in greater demand than chemists."

Dr. Conant gave no hint as to just what secret weapon was developed by the large group of scientists working at M.I.T.

THE MUSICIAN IN THE HIGH SCHOOL PHYSICS COURSE

Creed Grumbles
Senior High School, Ashland, Kentucky

Can the high school musician obtain anything of practical musical value from a course in high school physics? Yes, he can for in reality he is limited only by the things that limit him in other courses. First, there is the ever present lack of time. Then, there is the bogey of so much material to be covered to meet certain requirements. Too, there are the concepts of the wave theory of sound new to the pupil to be introduced. And then, too much attention can't be given to the music students to the exclusion of the other students.

The study of beats is one that is of importance to all the class, and a most practical one for musicians. It is unquestionably the best method of tuning. Piano tuners use it exclusively. A sensitive ear is not required; it is only necessary to know how and what to listen for. Most wind instruments are tuned by sounding a note the same pitch, or in octaves, to the tuning note. Thus, a musician who can detect beats can easily tell whether or not he is in tune.

Probably the next most important thing is the study of overtones. Here is a wide field for music students. For the other students the material is quickly forgotten if ever learned. The string player learns what determines the all-important quality of a tone; he learns that each tone is composed of many tones. The players that really profit from this study, however, are the brass players. A brass player will be surprised to learn that all the open tones on his instrument are overtones of a fundamental tone, and that all these tones can be located by physics.

An advanced cornet player will know that the B-flat below high C can be played as an open tone, but it is badly out of tune, being very flat. The reason for that is that it is the sixth overtone, and it is always discordant. The fundamental tone of the cornet is the pedal B-flat, and the overtones are as follows: C, G, C′, G′, E′, and B-flat′. The last is the note in question.

Perhaps a French horn player will then understand why the B-flat above middle C cannot be played as an open tone on his instrument. It is also the sixth overtone. The fundamental note on the French horn is an octave below low C, the overtones being as follows: C_1, G_1, C, E, G, B-flat.

For the same reason the A below high B-flat on the trombone can't be played in the first position.

The alto horn and the French horn give a perfect example of how the number of overtones change the quality of a note. The French horn plays an octave higher above its fundamental than does the alto horn, consequently its tone has many more overtones than does the alto horn, giving it a tone of much better quality. It also explains why a French horn is more difficult to play than other brass instruments; the open tones are much closer together, making it more difficult to be certain of a note.

The clarinet player can understand why by over-blowing low E he can play B, and the octave and a fifth above it, without using the octave key.

The laws governing the vibrations of strings will be of interest to string players, and will be of value in understanding harmonics.

In the study of changing pitch by changing the length of the air column an interesting fact can be told to the brass players. Since the length of the first and second value slides is equal to that of the third, any note played with the first and second values can be played by the third.

In reality there is no limit to the interesting and practical information for the high school musician in a physics course.

INTEGRAL RIGHT TRIANGLES

Ernest N. Brown
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The solution of right triangles plays an important part in algebra, geometry, trigonometry, and other courses in which the student needs practice in taking the square root of a number. Thus, square root is used in solving the equation: $c=\sqrt{a^2+b^2}$. The integral right triangles (those triangles all of whose sides are integers) are particularly useful at the beginning of the study of square root, as the younger student feels that he has really solved a problem if the answer comes out even.

Are there many integral right triangles? Yes, an infinite number; but too many texts use the same ones repeatedly: 3, 4, 5 (this indicates a right triangle having a hypotenuse 5, and the legs 3 and 4); 5, 12, 13; 7, 24, 25; or multiples of these such as: 6, 8, 10; or 30, 40, 50.

Unfortunately, if the same sets of figures are used repeatedly, the student memorizes the set instead of solving the problems. As a remedy for this lack of suitable integral right triangles, the following method by which any number of such triangles may be found is suggested.

Select any two odd integers (or any two even integers) a and d, so that a is exactly divisible by d (d may be 1 or larger). Then there is a right triangle having the sides a, b, and c with:

$$a=a$$

$$b=\frac{a^2-d^2}{2d}$$

$$c=b+d.$$

For example:

Let $a=12$ and $d=2$.

Then: $a=12$

$$b=\frac{12^2-2^2}{2\times 2}=35$$

$$c=35+2=37$$

and the right triangle is: 12, 35, and 37.

If the teacher goes through this brief operation, he has at his disposal a new set of figures from which he can make up his own problems. With the above example he could state: If a plane flies 12 miles south and 35 miles west, how far is it from its starting point? In this way the student has sufficient practice with square root, has practical applications, and has a variety of number sets with which to work.

BOOKS AND PAMPHLETS RECEIVED

A SURVEY OF MODERN ALGEBRA, by Garrett Birkhoff and Saunders MacLane, *Associate Professors of Mathematics in Harvard University.* Cloth. Pages xi+450. 14×21.5 cm. 1941. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.75.

BETWEEN THE PLANETS, by Fletcher G. Watson. Cloth. Pages v+222. 14.5×21.5 cm. 1941. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $2.50.

THE MILKY WAY, by Bart J. Bok and Priscilla F. Bok. Cloth. Pages v+204. 14.5×21.5 cm. 1941. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $2.50.

NATURAL HISTORY AND THE AMERICAN MIND, by William Martin Smallwood, *Chairman, Department of Zoology, Syracuse University* in Collaboration with Mabel Sarah Coon Smallwood. Cloth. Pages xv+445. 15×23 cm. 1941. Columbia University Press, Morningside Heights, New York, N. Y. Price $4.25.

THE PRINCIPLES OF FINANCIAL AND STATISTICAL MATHEMATICS, by Maximilian Philip, *Professor of Mathematics in the School of Business and Civic Administration of the College of the City of New York.* Revised Edition. Cloth. Pages xvi+335. 13.5×21.5 cm. 1941. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $3.50.

UNIVERSITY PHYSICS, PART ONE, GENERAL PHYSICS, by F. C. Champion, *Lecturer in Physics, University of London.* Cloth. 157 pages. 14.5×22 cm. 1939. Interscience Publishers, Inc., 215 Fourth Avenue, New York, N. Y. Price $1.50.

UNIVERSITY PHYSICS, PART TWO, HEAT, by F. C. Champion, *Lecturer in Physics, University of London.* Cloth. 148 pages. 14.5×22 cm. 1940. Interscience Publishers, Inc., 215 Fourth Avenue, New York, N. Y. Price $1.50.

UNIVERSITY PHYSICS, PART THREE, LIGHT, by F. C. Champion, *Lecturer in Physics, University of London.* Cloth. 172 pages. 1941. Interscience Publishers, Inc., 215 Fourth Avenue, New York, N. Y. Price $1.50.

LABORATORY EXERCISES IN PHYSICAL GEOGRAPHY, by M. H. Shearer, *Westport High School, Kansas City, Missouri.* Prepared to Accompany *The Earth and Its Resources,* by Finch, Trewartha, and Shearer. Paper. Pages viii+139. 19×26.5 cm. 1941. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $1.00.

HOW TO LOCATE EDUCATIONAL INFORMATION AND DATA, by Carter Alexander, *Library Professor, Teachers College, Columbia University.* Second Edition, Greatly Revised, Improved and Expanded. Paper. Pages xiv+439. 14.5×23.5 cm. 1941. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $4.00.

ALEXANDER LIBRARY EXPERIENCES, by Carter Alexander, *Library Professor, Teachers College, Columbia University.* For Use with the Second Edition of *How to Locate Educational Information and Data.* Paper. 158 pages. 21×28 cm. 1941. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.50.

A LABORATORY MANUAL OF ELECTRICITY AND MAGNETISM, by Leonard B. Loeb. Revised. Pages xii+121 plus a number of Experiments. 15×23 cm. 1941. Stanford University Press, Stanford University, California. Price $1.90.

POST-PLEISTOCENE FOREST MIGRATION AS INDICATED BY SEDIMENTS FROM THREE DEEP INLAND LAKES, by J. E. Potzger and Ira T. Wilson. Paper. Reprinted from *The American Midland Naturalist.* Vol. 25, No. 2. Pages 270–289, March, 1941. The University Press, Notre Dame, Ind.

THE VEGETATION OF MACKINAC ISLAND, MICHIGAN: AN ECOLOGICAL SURVEY, by J. E. Potzger. Paper. Reprinted from *The American Midland Naturalist.* Vol. 25, No. 2. Pages 298–323, March, 1941. The University Press, Notre Dame, Ind.

BANKING FACILITIES FOR BANKLESS TOWNS, by Shirley Donald Southworth, *Professor of Economics, College of William and Mary,* and John M. Chapman, *Assistant Professor of Banking, School of Business, Columbia University, and Economic Adviser to Bank of America National Trust and Saving Association,* California. Paper. 75 pages. 14.5×22.5 cm. 1941. John M. Chapman, P. O. Box 467, Grand Central Annex, New York, N. Y.

BOOK REVIEWS

A HISTORY OF MAGIC AND EXPERIMENTAL SCIENCE, Volumes V and VI: The Sixteenth Century, by Lynn Thorndike, *Professor of History, Columbia University.* Cloth. Pages: Vol. V: xxii+695. Vol. VI: xviii+766. 13.5×22 cm. 1941. Columbia University Press, Morningside Heights, New York, N. Y. Price $10.00 a Set.

These two volumes complete this unique history of magic and science. The period covered by volumes V and VI is from about 1500 to 1630. No brief review can give an adequate description of the wealth of material Professor Thorndike has brought together in this set. All students of the progress of civilization will find here a vivid picture of the conflict of ideas of the sixteenth century. The expanding horizons of that time produced a variety of interests, a spread of popular information, a reaction against the institutions of the Middle Ages, a confusion of religious beliefs, and a conflict of national loyalties and independent thought. All this is shown to result in many cases in confusion rather than in clear thinking and enlightenment. These volumes not only give a comprehensive treatment of all the facts on men and trends that can usually be found by research students but a considerable amount of material not previously brought to light. Some topics of especial interest are the susceptibleness of people in the highest places to be gulled by quacks and all types of imposters; the lack of freedom of thought and action; the censorship of the press; intolerance and escape therefrom. The books are filled with anecdotes, and personal sketches that portray character and depict life and customs. These are books for all students of the progress of education and of institutions, of the development of scientific thought, and of the revolution in religion.

G.W.W.

DYNAMICS OF INFLAMMATION, by Valy Menkin, *Department of Pathology, Harvard University Medical School.* Cloth. Pages xii+244. 15×22 cm. 1940. The Macmillan Company, New York, N. Y. Price $4.50.

The book is one of a series of monographs on experimental biology. As text it would be suited to the needs of medical students and professions concerned with health. It is a splendid monograph on the nature and function of inflammation in the animal body. While the language is somewhat technical for the average teacher of biology, the chapters on historical survey, mechanics and role of inflammation in protection to the organism can be read with much profit by any biology teacher. The author defines inflammation thus, "It can be broadly defined as the complex vascular, lymphatic, and local tissue reaction elicited in higher animals by the presence of microorganisms or of non-viable irritants. It represents a basic or elemental reaction to injury whereby the deleterious agent tends to be localized and ultimately destroyed. The inflammation reaction may be truly regarded as an immunological mechanism of definite significance."

Inflammation is accompanied by physical and physiological changes in

the area affected. The capillaries may become seven times more permeable than they are under normal conditions. The increased permeability is apparently caused by an exudate called leukotaxine, a nitrogenous substance. This induces rapid outward migration of polymorphonuclear leucocytes. As inflammation progresses, acidity is increased in the affected area (*p*H 6.8) and this favors movement of macrophages to the region, while the polymorphonuclear leukocytes degenerate. Exudates from inflamed tissues indicate that a leukocytosis-promoting substance is present which apparently acts on the bone marrow, producing an outpouring of immature granulocytes into the circulatory system; leukotaxine favors merely their movement through the capillaries. The author summarizes as follows, "An inflamed area can be considered as shunted off from the rest of the organism. It has its own metabolism, its own hydrogen-ion concentration, and its own modified circulation. The inflammatory reaction thus displays an extraordinarily complex mechanism tending to localize and dispose of a chemical or bacterial irritant. This ultimately leads to organization and repair of the affected tissue."

J. E. Potzger
Butler University

A College Course of Inorganic Chemistry, by J. R. Partington, *Professor of Chemistry in the University of London, Queen Mary College.* Cloth. Pages x+658. 13.5×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.50.

This book is designed for a college course in Inorganic Chemistry for students who have had high school chemistry. The author states that his more comprehensive book, *A Text-Book of Inorganic Chemistry* served as a foundation for the general plan and method of treatment of the new book but that the text had been largely rewritten and rearranged.

The arrangement of the book is not that found in most college chemistry texts. The first chapters deal with general principles and a review of elementary topics. Then follows a discussion of the elements oxygen, hydrogen and the halogens, and their compounds. Three chapters on Physical Chemistry are followed by the chapter on the Periodic Law and Atomic Structure. The elements are then taken up in the order of the groups of the Periodic Table; metals and non-metals are taken together.

Outstanding features of the book include the historical development of many topics, the large number of equations given, and the numerous experiments described and diagrammed. There are few numerical problems in the text because, as the author states, these are dealt with fully in the book *Intermediate Chemical Calculations*, by Partington and Stratton. Very few references are cited. Recent examination questions dealing with topics covered in each chapter are grouped in a section toward the end of the book.

Numerous industrial processes are described, those of historical interest as well as ones in use at the present time. The preparation and properties of many compounds of the elements are taken up in detail. In some cases several preparations are given with no attempt made to point out the ones usually employed commercially or those most convenient in the laboratory.

It is the opinion of the reviewer that this book is too comprehensive to be used as a text by the average college student not majoring in chemistry. Advanced students and teachers should find it very useful as a reference book.

F. B. Schirmer, Jr.
University of Illinois
Urbana, Illinois

THE DOZEN SYSTEM, by George S. Terry. Paper. Pages viii+63. 23.5×29 cm. 1941. Longmans, Green and Co., 55 Fifth Avenue, New York, Price 50 cents.

A booklet of attractive appearance setting forth the advantages of the duodecimal system (base 12) versus the present decimal system in computation. The author shows how conversion to other bases is performed, how to perform the four fundamental operations with integers, decimal and common fractions, factorization, involution and evolution in the duodecimal system. Multiplication is performed by means of special charts which are an adaptation of Napier's Bones. The author gives further applications to plane geometry, trigonometry and geography, and shows how this system is superior in a number of commercial applications. For example, the saving of space in printing time tables would be considerable, with no confusion between morning and evening trains. A protractor and a slide rule in the dozen system are illustrated, and the method of computing the approximate value of duodecimal pi is given. The pages of the book itself are numbered according to the dozen system, and the book concludes with a list of references on this system dating back to 1866.

GLENN F. HEWITT
Von Steuben High School
Chicago, Ill.

A MATHEMATICIAN'S APOLOGY, by G. H. Hardy. Cloth. Pages vii+93. 12×18.5 cm. 1940. Cambridge: At the University Press, New York: The Macmillan Company, 60 Fifth Avenue. Price $1.00.

Why it is really worth while to make a serious study of mathematics? What is the proper justification of a mathematician's life? Is mathematics "unprofitable"? Is mathematics "harmless"? What is meant by a "useful" science or art? What parts of mathematics are useful? What makes a mathematical theorem important? What two essential qualities make a mathematical idea "significant"? What is the distinction between "real" and "trivial" mathematics? How do pure and applied mathematics differ? Is the mathematician's work worth doing? Why does he do it?

A distinguished English mathematician tells in this vignette volume how he would answer these questions. Developing his answers with good humor, he makes a number of confessions and presents the reader with a variety of inspirational and challenging ideas. He tells the reader, for example, that a mathematician need not now consider himself on the defensive; that mathematicians as a class are not particularly distinguished for general ability or versatility in other lines; that mathematics is a creative art and as such is a young man's game, since a mathematician is likely to lose the power or the desire to create rather soon; he confesses his inability to recall any major mathematical advance initiated by a man past fifty and further confesses himself to be past sixty. "What the public wants is a little intellectual kick, and nothing else has quite the kick of mathematics." This accounts for the popularity of chess, bridge and puzzle problems. "Chess problems are the hymn tunes of mathematics."

After informing the reader that the best mathematics is both serious and beautiful, he proceeds to define what he means by "serious" and "beautiful" and then states and proves some very simple theorems of the highest class and discusses some of their implications. The author treads on the toes of scientists by saying "A little chemistry, physics or physiology has no value at all in ordinary life. I have never once found . . . where such scientific knowledge as I possess . . . has brought me the slightest advantage. . . . When our cars break down, we take them to a garage; when our stomach is out of order we go to a doctor. We live either by rule

of thumb or on other people's professional knowledge," and he might well have added that when we do so we are often taken advantage of because of our ignorance. He defines what he considers makes a subject or art "useful," and concludes that very little of mathematics is useful practically and that little is comparatively dull. When he tells us that Euclidean geometry is useful in so far as it is dull, he reminds one of the famous remark of Mr. Dooley that "it makes no diffruns phwat a bye stidies in school, jist so he don't loike it." He concludes that the mathematician's life is justified in the sense that he has added something to knowledge and helped others to add more, and that these added somethings compare favorably with the contributions of artists in other fields.

GLENN F. HEWITT

A FIRST YEAR OF COLLEGE MATHEMATICS, by Henry J. Miles, *Associate in Mathematics, University of Illinois*. Cloth. Pages xvii+607. 14.5×22 cm. 1941. John Wiley & Sons, Inc., New York, N. Y. Price $3.00.

The material is definitely a unified course in Freshman Mathematics, not a superficial or survey course. It includes the subject matter of Algebra, Trigonometry, Plane and Solid Analytic Geometry, and Elementary Differential Calculus. The last chapter is devoted to the foundations of Algebra treated with more rigor than is customary in Freshman courses. The subject matter starts with Analytic Geometry. It provides opportunities for some unusual methods of treatment, for example: the development of the formulas for the sine and cosine of the sum of two angles from the formulas of rotation of axes. There is a very good discussion of systems of n equations in n unknowns. An unusual treatment brings in the concept of direction cosines of a line in the plane. This results in a slight variation in the normal form of the equation of a line.

The treatment is in general quite rigorous. For example: in discussing removal of the xy-term by rotation, the author carefully considers the possibility of a division by zero arising. On the other hand, in his discussion of the locus of $y=mx$, the Freshman will encounter trouble if he tries to find out if the discussion still holds with $m=0$. One might wonder at the omission of any mention of the principal value of the inverse secant and cosecant.

There is a large number of problems with answers to the odd numbered ones furnished. There are four place tables of common logarithms and of the natural and logarithmic trigonometric functions; a table of powers and roots; and a five place table of natural logarithms.

In spite of the somewhat startling arrangement of material (as for example when progressions follow an extended treatment of the derivative) the book seems to offer very definite possibilities for a year course.

CECIL B. READ
University of Wichita

FUNDAMENTALS OF MATHEMATICS, by M. Richardson, *Ph.D., Instructor in Mathematics, Brooklyn College*. Cloth. Pages xviii+525. 16×24 cm. 1941. The Macmillan Company, New York, N. Y. Price $3.25.

The content of this text is definitely unusual. The author claims that what he classes as the fundamental ideas of Mathematics are not concepts which can be grasped only at the graduate school level. He feels that his subject material is "more intelligible, more useful, more appealing, and more appropriate . . . than most traditional Freshman topics." As an example of some topics included, one might list several chapter headings: Logical Mathematics and Science; The Logic of Algebra; Impossibilities and Unsolved Problems; Cardinal Numbers Finite and Transfinite; Euclidean and Non-Euclidean Geometry.

The introductory chapter, containing advice to the student, is excellent. Rather than the traditional set of examples and problems, one frequently finds exercises which would require careful thought and possibly rather extended discussion. Answers are provided to the odd numbered exercises.

Whether or not one believes that this material can be successfully presented to Freshman students, it cannot be denied that one should consider the possibility of such presentation. A text of this nature would at least be a valuable addition to the library of the institution. Many of the concepts would prove interesting to high school students above the average of ability. The treatment is in general quite rigorous, as is illustrated in the discussion of fractional exponents. The definition of the mantissa of a logarithm is at least unusual.

CECIL B. READ

GENERAL BIOLOGY, Revised Edition, by James Watt Mavor, *Professor of Biology, Union College, Schenectady, New York.* Cloth. Pages xxx+897. 16×23.5 cm. 1941. The Macmillan Company, New York, N. Y. Price $4.00.

This revision of a biology text which was first published in 1936 retains the general organization of the first edition. The greatest changes will be found in the beginning sections of the book. In Part I the methodological and historical approach of the first edition has been replaced by a systematic and ecological approach in the first three chapters. The sections containing a discussion of the cell principle and protoplasm have been revised and the part on cell physiology enlarged.

In Part II the sections dealing with the survey of the plant kingdom have been enlarged and treated in greater detail. The chapter on Adaptation, Distribution and the Balance of Nature contained in the first edition has been omitted in the revised edition, but the material is discussed under other topics.

The text is composed of five approximately equal parts. The first is concerned with a discussion of ecology and protoplasm, the second is devoted almost entirely to a discussion of the plant kingdom, the third deals with the animal phyla, the fourth contains a discussion of the anatomy, physiology and reproduction of frog and man and the fifth part is devoted to principles of development, heredity and evolution. At the end of each chapter there are questions which should be helpful to the student and usually one or more references for additional reading.

The final section of the book which deals with development, heredity and evolution is very well done in the revised edition as it was also in the first edition. In the plant section, however, the author has fallen into the usual error of emphasizing material of least interest to most students and of neglecting almost entirely the more interesting experimental phases of plant study. In his discussion of tropisms he has entirely omitted the subject of plant hormones which has recently occupied the center of attention of many plant investigators and concerning which our knowledge has been much enlarged, especially during the last ten years. The remaining sections of the book are well done and the illustrations are ample and usually well chosen.

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When you change address be sure to notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.

Brilliant as was the work of the brothers Wright, the crown of achievement will not be truly won until a grateful mankind sees that the wings gained are the wings of a dove and not those of a bird of prey.—H. E. WIMPERIS.

CONTENTS FOR DECEMBER, 1941